

MINES BRANCH
DEPARTMENT OF THE INTERIOR.
HONOURABLE FRANK OLIVER, M.P., MINISTER.

PRELIMINARY REPORT

ON THE

**Raw Materials, Manufacture and Uses of
Hydraulic Cements in Manitoba.**

BY
J. WALTER WELLS.

OTTAWA, CANADA.

1905.

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OTTAWA, May 4th, 1905.

SIR,—

I have the honour to transmit herewith a Preliminary Report on the raw materials, manufacture and uses of Hydraulic Cements in Manitoba.

I have the honour to be,

Sir,

Your obedient servant,

(Sgd.) EUGENE HAANEL,

Superintendent of Mines.

HON. FRAN AVER, M.P.,
Minister of the Interior.

OTTAWA, 30th May, 1904.

DEAR SIR,

You are hereby directed to proceed at the earliest moment after receipt of this letter of instruction to Manitoba and the North-West Territories for the purpose of investigating the different deposits of Limestone, Clay and Shale which may be employed in the manufacture of Cement, and to visit the Cement Mills in North Dakota, in Minnesota and South Dakota, for the purpose of studying the different methods used in the manufacture of Cement, and to gather such other information as will enable you to complete your former investigations on this subject, and write a report on the making of Hydraulic and Portland Cement from the raw material obtained from the deposits in Manitoba and the North-West Territories, which will be of practical value in furthering the Cement Industry of the province

Yours very truly,

EUGENE LAANEL,

Superintendent of Mines.

J. WALTER WELLS, Esq., B.Sc.,

392 Markham Street,

TORONTO, ONT.

OTTAWA, 6th March, 1905.

SIR,—

I have the honour to transmit herewith a preliminary report on the raw materials, manufacture and uses of Hydraulic Cements in Manitoba. This involved the examination of the limestones, marls, clays, shales and coal deposits of Manitoba so far as could be done in a preliminary field survey during a period of five months.*

The facts were collected as far as possible by personal observation. What use can be made of them and what advantage derived from them rests with the energetic people of Manitoba, for whose benefit they have been collected and for whose information they are now presented.

The analyses, unless otherwise stated, have been made by M. F. Connor, official chemist.

I wish to express my thanks for the advice and suggestions you have given me.

I have the honour to be,

Sir,

Your obedient servant,

J. WALTER WELLS.

DR. EUGENE HAANEL,

Superintendent of Mines,

OTTAWA.

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I.—PRESENT INDUSTRIAL CONDITIONS IN MANITOBA.

The present industrial condition of Manitoba calls for an active propaganda in favour of utilizing the local natural deposits of limestone, clays and shales for building purposes in order to assist in the natural economic development of the Province. The production of wheat and other cereals is the main source of wealth in the Province and a succession of good crops has placed the earlier settlers in a position to build a better class of dwelling houses, barns, stables, etc. The great fertility of the soil in Manitoba and the ease with which it can be prepared to produce cereals, combined with the fact that the Dominion Lands Department is ever ready to furnish information regarding the unoccupied land, have attracted emigrants from Great Britain and European States. Many of the wealthy farmers in Western United States are realizing the fact that they can sell their own farms and with the proceeds purchase three farms equally as good in Manitoba. So that a steady stream of settlers is coming into the Province and new buildings are being erected.

A cheap, strong and warm building is demanded on the farm and lumber is at present the common material used for farm buildings, as it is convenient to handle. But, unfortunately, the lumber must be imported from British Columbia, Western Ontario, and the Western American States, so that the cost of production combined with transportation charges makes the price of lumber in Manitoba very high, in fact almost prohibitive.

Fortunately, the Province is well supplied with natural deposits of limestone, clays, shales, gravel and sand, so that by expending money and energy in the proper direction cheap building materials may be produced, of a quality suitable for supplementing or even supplanting lumber and wood in the construction of all grades of houses, stores, elevators, barns, etc. These natural deposits seem to be a valuable asset to the Province, giving it the privilege of dropping to a considerable extent the use of wood for building purposes, if at any time the price should rise.

By utilizing the local materials home industries would be started, employing many hands and keeping money within the Province which otherwise would go out in payment for lumber imported. So that self-interest should prompt the people of Manitoba to utilize the local raw materials, especially since ex-

pensive experiments are not necessary as brick, quarry stone, cement concrete and tile have stood centuries of trial in competition with wood as reliable building materials.

The limestone quarries near Tyndal, around Stonewall, and at the Narrows on Lake Manitoba are now producing first grade building stone and rubble for concrete, which is shipped to all parts of the Province, especially to the City of Winnipeg, where building operations are active.

Large beds of clay are quite common throughout the country, and at points where cheap fuel and transportation facilities are available brick-making plants are now producing bricks which seem to be the popular building material in the towns and villages, but as yet the price, averaging \$10.00 per thousand, is too high for common use on the farm. But sand and gravel are quite common, especially in the hilly sections, so that along with cheap Portland or natural cement, they can be used for the construction of cheap and serviceable farm buildings.

Portland cement is not made in the Province, but is imported from the cement factories in Ontario, such as at Owen Sound, Durham and Hanover, having convenient shipping facilities to the west. The American cement factories, especially those located in Michigan and in Illinois, are also shipping Portland cement to Manitoba. The average price for Portland cement laid down at Winnipeg is about \$2.75 per barrel.

There is apparently no reason why Portland cement should not be made in Manitoba as the raw materials are available, while labor and other costs are gradually being lowered, so that sooner or later it will probably be cheaper to make cement in Manitoba than to import.

Natural rock cement is being made by the Manitoba Union Mining Company at Arnold. This cement finds a market, especially on farms, but has been used for the same purposes as Portland cement in railway construction.

II.—SKETCH OF THE MANUFACTURE OF HYDRAULIC CEMENT.

DEFINITION OF HYDRAULIC CEMENT.

Hydraulic Cement, as used in an engineering sense, means such a chemical combination of alumina, lime, silica and iron that when properly powdered and mixed with a proper amount of water it has the property of hardening under water and in contact with moist air.

Limestones carrying 8% or more clay, when properly burned, produce hydraulic limes and cements. There is no hard and fast distinction between these two materials except that the cements have stronger setting qualities.

Two classes of hydraulic cement may be made in Manitoba and used to good advantage in engineering work and buildings of every description: (1) Portland cement* (2) natural rock cement.

PORTLAND CEMENT.

Portland or Artificial Cement.—A chemical compound, consisting essentially of lime, silica and alumina obtained by burning at a sintering temperature an intimate mechanical mixture of a definite proportion of pure carbonate of lime and clay of pure quality, the product being subsequently ground to a more or less impalpable powder.

RAW MATERIALS.

The necessary materials for Portland cement are:—

1. Carbonate of lime, usually in the form of bedded limestone, crystalline limestone, chalk or marl.
2. A natural mixture of limestone and clay, such as the argillaceous limestones of the Lehigh Valley, Penn.
3. Clay or silicate of alumina more or less pure.
4. Shale which is indurated clay, often carrying more or less carbonate of lime.

True Portland cement of uniform and reliable quality can be made only from an artificial mixture of the raw materials. So far no natural deposit of limestone has been found having uniform composition with the right amount of clay. A variation of 1%

*Portland cement was invented in 1824 by James Aspdin, a bricklayer of Leeds, England, and was so called because it resembled in point of colour and texture the oolitic limestone from the island of Portland.

in composition from the correct standard is sufficient to reduce the value of the resulting cement.

Carbonate of Lime for use in making Portland cement must have the following qualities:—

It should be as pure as possible except for the presence of pure clay which may be present in considerable quantity. The presence of magnesia is deleterious for the reason that it does not seem to combine with the clay at the temperature required for the burning of the cement and is left at the end of the process as caustic magnesia (MgO). When water is added to cement containing magnesia the magnesia seems slowly to absorb water, forming a hard product of increased volume, hence producing a cracking or disintegration of the hardened cement even after several years. The precise allowable limit of magnesia is still undecided, but 3% seems to be the maximum allowed in first grade cement.

Sulphate of lime (gypsum) in quantities exceeding 2% is objectionable in the raw material, as it is reduced to a sulphide in the reducing flame of the rotary and vertical kiln, causing the cement to turn a dark blue colour in hardening and to give poor tests and unsightly concrete.

Hard pure limestones have the drawback of the high cost of pulverizing the large quantity required to the necessary fine powder. Limestones carrying a considerable quantity of clay are much better as they are generally softer and much coarser grinding will suffice to obtain a good combination in burning, as the mixing is already partly done by nature.

Free sand and an excessive amount of organic matter are common objectionable impurities of marl, as the sand does not combine readily while the organic matter tends to clog the kiln, consuming fuel without adding to the output of cement.

The chemical composition of certain typical forms of carbonate of lime used in the manufacture of Portland cement is given by the following partial analyses made by the writer:—

	(1)	(2)	(3)
Silica, SiO_2	4.24	0.86	17.24
Alumina, Al_2O_3	3.45	0.92	7.32
Ferric oxide, Fe_2O_3	1.30	1.04	2.09
Lime carbonate, $CaCO_3$	90.32	93.24	68.74
Magnesium carbonate, $MgCO_3$	0.50	0.26	4.36
Lime sulphate, $CaSO_4$	trace	trace	0.36

- (1) Chalk used at Western Portland Cement Works, Yankton, South Dakota, U.S.A.
- (2) Marl used at Ontario Portland Cement Works, Brantford, Ontario.
- (3) Argillaceous limestone used Lawrence Cement Works, Siegfried, Pennsylvania, U.S.A.

Chalk and argillaceous limestone are ideal raw materials for the manufacture of cement because they are generally soft and pure.

In England a soft chalk is generally used. In Germany chalk, limestone and mergel (soft, clayey limestone) are the common materials. At Yankton, South Dakota, a pure soft dry chalk is used, producing a first grade cement.

In Pennsylvania and New Jersey argillaceous limestone, containing slightly more clay than is required for a correct mixture, is mixed with pure limestone. The grinding of the raw material is comparatively coarse since the bulk of it is already of nearly correct composition and is not expensive as the stone is medium soft.

In Ontario marl is used at the nine factories in operation but one factory is being constructed to use hard bedded limestone.

In Michigan both marl and hard bedded limestone are used. In Kansas a Cretaceous limestone is used in all of the factories.

Clays and Clay Shale.—These should be low in magnesia and sulphates, high in combined silica, but practically free from sand, as the latter does not combine to form silicate of lime at the temperature obtained in burning cement clinker. The presence of sand may be proved by the washing of powdered clay and shale through a fine sieve. According to S. B. Newberry, who has conducted laborious researches on cement, the silica in clay should be equal to at least three times the alumina and iron oxides together. For example, a clay containing 18% Al_2O_3 and 4% Fe_2O_3 should contain at least 66% SiO_2 .

Clays high in alumina produce a fusible clinker and a quick setting cement. Clays high in silica up to 70% SiO_2 show mixtures standing high heat in the kiln without fusing, and producing a slow setting cement which being set steadily increases in strength.

Iron oxides lower the fusion point of cement clinker in burning, hence reduce the cost of burning. Clay carrying more than 5% of iron oxides will give a dark colored cement and the lower the percentage of iron oxides the lighter in color the cement will be.

Alkalis are usually present in small quantities and seem to assist in making the clinker more fusible.

The most desirable clay or shale is one free from the above mentioned impurities, containing sufficient alumina and iron oxides to render the clinker easily fusible, but not enough to make the cement quick setting and reduce the proportion of tri-calcium silicate ($3\text{CaO}, \text{SiO}_2$) which is the active ingredient in making the cement harden on the addition of water.

PROPORTION OF INGREDIENTS.

The chemist in a cement factory has a responsible position as he alone can determine the exact proportions in which the raw materials shall be mixed to produce a combination of satisfactory grade. The composition of the mixture must be under the control of the chemist and the percentage of lime kept within 0.5% of the limit.

Laborious researches on the composition of cement have been made by Messrs. Newberry (Journal of Society of Chemical Industry, November, 1897, page 889).

By synthesis they determine that:

1. Lime may be combined with silica in the proportion of 3 molecules to 1 to form ($3\text{CaO}, \text{SiO}_2$) and still give a product of practically constant volume and good hardening properties, though hardening very slowly. With 3.5 molecules of lime to 1 of silica ($3.5 \text{CaO}, \text{SiO}_2$) the product is not sound and cracks in water.
2. Lime may be combined with alumina in the proportion of 2 molecules to 1 ($2 \text{CaO}, \text{Al}_2\text{O}_3$), giving a product which sets quickly but shows constant volume and good hardening properties. With 2.5 molecules of lime to 1 of alumina ($2.5 \text{CaO}, \text{Al}_2\text{O}_3$) the product is not sound.

The formula $3 \text{CaO}, \text{SiO}_2$ corresponds to 2.8 parts lime (CaO) to 1 part silica (SiO_2) and the formula $2 \text{CaO}, \text{Al}_2\text{O}_3$ corresponds to 1.1 parts lime (CaO) to 1 part alumina Al_2O_3 and, therefore, the following formula is given as representing the maximum of lime in an ideal Portland cement:—

$$\% \text{CaO} = \% \text{SiO}_2 \times 2.8 + \% \text{Al}_2\text{O}_3 \times 1.1.$$

By experimental synthesis of Portland cement with mixtures

containing various percentages of alumina they show that cement made according to the above formula gives satisfactory results, while cement containing 3 molecular proportions of lime to 1 of alumina, according to the maximum laid down by Le Chatelier's formula, is unsound, thus showing that the lime limit has been exceeded.

Newberry's formula is commonly used in Canadian cement factories.

MIXING OF RAW MATERIAL.

When marl and clay are used as raw materials they are usually mixed by a wet process. After being thoroughly stirred and mixed with water in separate wash mills, the materials are pumped into separate measuring cylinders and drawn off as required into a mixing pan supplied with an agitator and then through tube mills and emery mills to thoroughly pulverize the mixture or slurry which passes into storage pits, where it is sampled and analyzed by the chemist, who allows the slurry to pass into the rotary kilns, if it is satisfactory, or calls for more marl or clay, if required.

At many factories using marl and clay the wet materials are mixed in a plastic condition and fed directly into the rotary kilns in the form of wet pulp.

It is claimed that a wet mixture is more perfect than a dry one, but the product requires more fuel to produce the cement clinker, owing to the fuel consumed in evaporating the large amount of water present.

At some modern cement factories in Ontario the marl is calcined in separate rotary kilns, driving off water, organic matter and a portion of carbon dioxide; the product, after being mixed with the correct amount of dried clay, is ground in Griffin mills and passed to the clinker kilns.

When the raw materials are naturally in a more or less dry condition and more or less perfectly mixed by nature, the dry mixing process is preferable and is the common practice in the Lehigh Valley and New Jersey cement mills, which produce 60% of the cement used in the United States. The dried materials are pulverized, 85% passing a 100-mesh screen, again moistened to prevent dust, and burned in rotary kilns.

Improvements are being made to use the waste heat from

the clinker kilns for drying the crushed rock. Gyratory crushers are used for coarse crushing. Emery mills, griffin mills, ball mills and tube mills are generally used for dry grinding of the coarse crushed raw materials. If the raw material, such as argillaceous limestone, is already approximately of the correct composition coarser grinding is allowed, thus saving some expense.

CALCINATION OF THE MIXTURE.

The calcination of the mixture is done both in vertical kilns and tilted rotary kilns.

Of the different forms which have been in use, the rotary kiln has proven the best adapted to the process of producing a satisfactory clinker, having the following advantages: -

1. A reduction of labor as the process is automatic and continuous.
2. The raw material does not require to be briquetted before entering the kiln, as in the case of vertical kilns, thus saving labor, time and expense.
3. The process admits of complete control and a uniform product. The operator in charge of the kiln has three variables at his command—the feed of the mixture, the speed of the kiln and the feed of the pulverized coal forced in by air blast.

The rotary cement kiln consists of a slightly tilted steel cylinder, from 60 feet to 100 feet in length, and about 7 feet in diameter, lined with fire brick and revolving on rollers at about one revolution in two minutes, effected by a large gear surrounding the shell about half-way from either end. The speed can be varied by means of a counter shaft. Dried, pulverized bituminous coal, carrying 30% or more of volatile combustibles, is generally used for fuel and is driven in at the lower end by an air blast giving a temperature of about 3,000° F. in the hottest zone, extending from 5 to 30 feet back. The dried coal is usually pulverized in Griffin mills or ball mills followed by tube mills so that 95% passes a 100-mesh screen.

The rotary kiln usually requires 110 pounds of dried pulverized bituminous coal per barrel (280 pounds) of cement, so that fuel costs are higher than in the case of the vertical kilns.

but improvements are being made by cement engineers to utilize the waste heat from the clinker kilns in drying the raw material before calcination.

A new style of rotary kiln, 150 feet in length and 9 feet in diameter, has recently been put in operation at the immense plant of the Edison Cement Works, Stewartsville, New Jersey. It is claimed that this kiln reduces the cost of production $3\frac{1}{2}$ cents per barrel of cement by using less coal.

The vertical kilns are so little used in modern Portland cement factories that they may be considered as obsolete. Their great advantage is low cost of fuel per barrel of cement.

CLINKER.

A properly burned clinker should be dense in texture and greenish black in colour. Over-burned clinker is fused and slag-like and is usually slow in hardening, though it may show good tests after some time. Long continued burning and an excess of clay produce a clinker which powders on cooling and has little or no hydraulic properties.

Under-burned clinker is brownish-yellow in colour, soft and quick setting, but is liable to crack in hardening, owing to the presence of uncombined or free lime which absorbs water and expands.

GRINDING OF CLINKER.

Portland cement clinker is usually pulverized in a Griffin mill or in a German ball mill followed by the tube mill. Sometimes upright emery mills are used in place of the tube mill. A fine powder, 95% passing a No. 100 sieve (10,000 meshes per square inch) is usually made in Canadian cement works. Finer grinding is expensive and not at present demanded by the users of cement.

Revolving screens are usually adopted for sifting the ground clinker. The oversize from the screens is returned to the emery mill or tube mill for regrinding.

The new Edison works in New Jersey have adopted a system of winnowing or separation of different powders from fine to coarse by air blasts working on pulverized clinker.

STORAGE.

The pulverized clinker passing through the screens is transferred to storage bins feeding automatically to barrels or bags which are secured ready for shipment.

It is safer to allow the fresh cement to remain in dry storage houses for a few days so that any free lime in the cement may be converted into carbonate of lime and rendered inert.

COMPOSITION.

No Portland cements made from different raw materials can have exactly the same composition, but all high grade cements must have approximately the same proportion of each of the various constituents. The limits of the proportionate quantity of each constituent of high grade cement have been established, both practically by cement engineers and theoretically by scientists. It is beyond the province of this paper to discuss this part of the subject. Suffice to say that high grade Portland cement, no matter where it is made, must conform very closely to the following composition:—

Silica, SiO_2	from 20 to 24%
Alumina, Al_2O_3	" 6 " 9%
Iron oxide, Fe_2O_3	" 2 " 5%
Lime, CaO	" 60 " 65%
Magnesia, MgO	" 0 " 3%
Sulphur trioxide, SO_3	" 0 " 2%
Alkalies, Na_2O and K_2O	" 0 " 3%

NATURAL ROCK CEMENT.

Natural Rock Cement is made by calcining at a moderate heat either an argillaceous limestone or a calcareous shale, which contain an excess of clay over the proportion required for Portland cement and generally a considerable quantity of magnesia. The calcination of these materials produces more or less incipient vitrification of the contained lime and clay.

Natural Rock Cement has been made and used for centuries. Its manufacture and proper manipulation seem to have been well understood by the Romans.

RAW MATERIALS.

Most of the clay bearing limestones and calcareous shales in Canada contain a high percentage of magnesia and an excess of clay and are, therefore, unsuitable for the manufacture of Portland cement. If such materials are burned at the high temperature necessary to produce a good cement clinker, they fuse to a slag which after grinding has little or no hydraulic properties.

If burned at a lower heat (1,200° F.), however, the carbonic acid being driven off, they give a soft, yellowish clinker, which after grinding yields the natural rock cement, of which Queenston and Thorold cements are examples.

The actual chemical proportions required for first grade Portland cement cannot be obtained in natural rock cement, for the reason that the natural rock is seldom of a uniform quality as it comes from the quarry. In making natural cement the value of the resulting cement depends on the proportions of lime, silica and alumina in the rock and will be either good or bad as the natural material corresponds more or less nearly to the proper proportion for good cement.

COMPOSITION OF NATURAL CEMENT ROCKS.

The following partial analyses show the composition of natural cement rocks at different cement works:—

	(1)	(2)
Moisture.....	0.92	1.97
Silica.....	20.38	18.13
Alumina.....	4.33	7.40
Ferric oxide.....	2.87	2.93
Lime.....	25.98	34.44
Magnesia.....	11.16	0.61
Alkalis.....	1.34	1.47
Sulphur trioxide.....	1.48	1.72
Carbon dioxide.....	31.33	26.62
Undetermined.....	0.21	4.71
	100.00	100.00

- (1) Argillaceous magnesian limestone, Usher Cement Works, Queenston, Ontario, sampled by the writer in 1902, and analysed by the Government Assayer for Ontario.

- (2) Calcareous shale, Arnold Cement Works, Manitoba, sampled by the writer in 1902, and analysed by the Government Assayer for Ontario.

MANUFACTURE OF NATURAL CEMENT.

The methods of making natural cement are cheap and simple, involving only the operations of mining, calcining and grinding.

MINING.

Different methods of mining are employed, as best adapted to the deposit. In the Rosendale district, New York, the rock is mined by open quarry work of the large deposits of suitable rock requiring little stripping or by tunnelling.

At the Queenston Cement Works in the Niagara district, Ontario, the suitable rock is obtained by tunnelling into the high escarpment of limestone about 100 feet from the top and the suitable rock, after sorting, is carried by service cars direct to the kilns built on the face of the cliff.

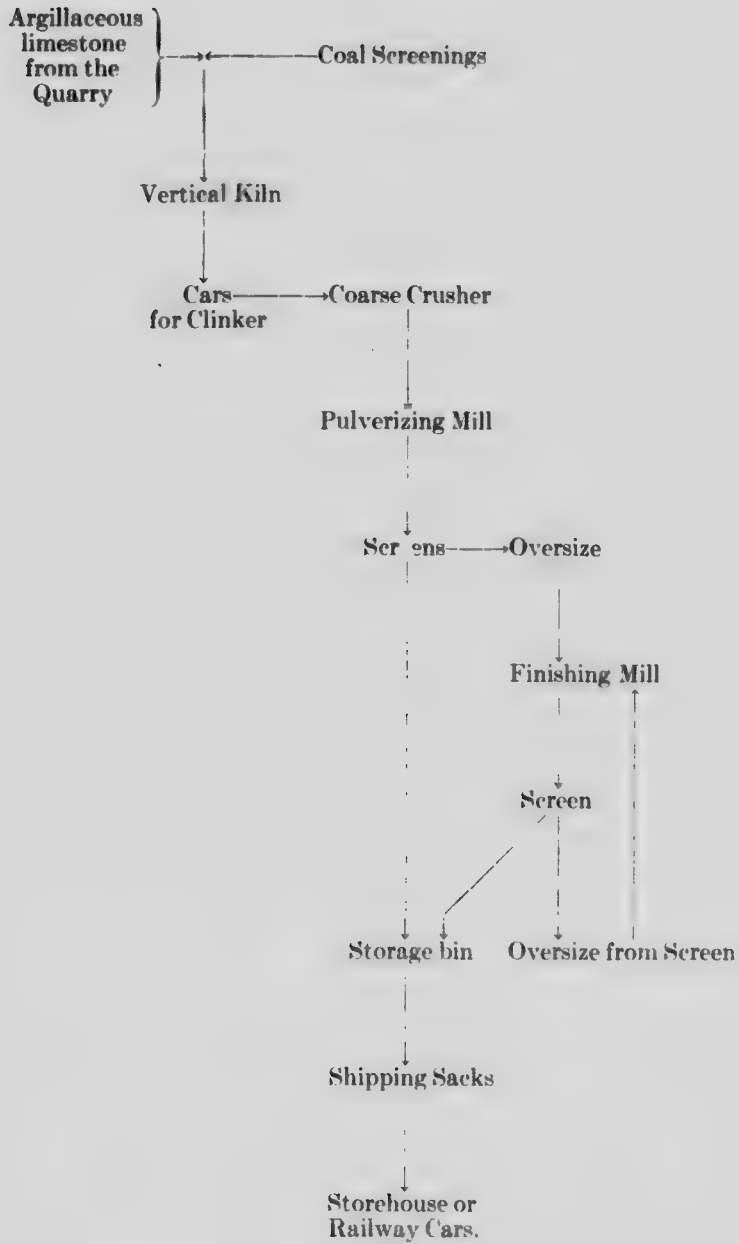
At the Thorold Cement Works in the same district a bed of argillaceous limestone is overlaid by unsuitable limestone. The natural cement rock is obtained by a tunnel and is hauled by horses and carts to the pot kilns built on the face of a small bluff.

At the Arnold Cement Works in Manitoba the calcareous shale found as horizontal beds about 20 feet thick is obtained by tunnelling into the bottom of the hill and is delivered by wheelbarrows to an inclined bucket elevator hoisting the material to the feeding floor of the vertical kiln, as shown in Plate No. 2.

At the works of the Pembina Portland Cement Company, Tongue River Valley, Cavalier County, North Dakota, the horizontal bed of suitable soft calcareous shale is said to be 45 feet thick. A main tunnel 7 feet high is run into the bed of shale at the bottom of the hill and the material is removed by drifting on each side of the main tunnel and is hauled on mine cars to the entrance of the tunnel. The cars are then hoisted up an inclined tramway to the top of the vertical kilns and dumped as required.

SCHEME OF OPERATIONS FOR MAKING NATURAL ROCK CEMENT.

A typical natural rock cement plant has the following scheme of operations, all material being handled by machinery and the different parts so arranged that the force of gravity comes into play:—



CALCINING OF MATERIAL.

The kilns used for calcining natural cement rock are all of the vertical up-draft type employed in making lime by calcining limestone. The vertical shaft is generally cylindrical in shape, open at the top with a charging floor for the rock and fuel and drawn into an inverted cone at the bottom.

The rock coming from the quarry without any further reduction in size is charged at the top of the kiln in alternate layers with coal and the clinker, more or less perfectly burned, is drawn out at the bottom.

The operation is continuous and the temperature of burning is comparatively low ($1,000^{\circ}$ to $1,200^{\circ}$ F.) so that the output of cement per ton of coal is large, often running 90 barrels per ton of coal.

The burnt rock falling from the bottom of the kilns is carefully sorted to eliminate the under-burnt and the over-burnt clinker and dumped into cars beneath, running to the grinding room.

Bituminous coal screenings are generally used as fuel, but at the Arnold plant in Manitoba lignite coal is used. At the same plant the cylindrical kiln made of boiler plate lined with fire brick has the charging floor on a level with the Canadian Northern Railway track, so that coal is easily handled, while the rock is hoisted by a bucket elevator, as may be seen in the photo of this kiln, Plate No. 2.

An admirable arrangement is used at the Usher Cement Works, Queenston, Ontario, where the kilns are built of rough dressed stone on the face of the cliff, so that mine cars run from the tunnel and from the coal bins to the top of the kilns, where they are dumped.

GRINDING OF CLINKER.

Natural cement clinker is usually pulverized by passing through a cone crusher, followed by a Griffin mill or a horizontal bur mill in which steel plates are substituted for stones. The calcined rock is quite soft and easily reduced to a powder passing a 100-mesh screen.

COMPOSITION OF NATURAL CEMENT.

The composition of natural rock cement varies with the raw material used and the method of burning. The following analyses serve to show the variation in composition:—

	(1)	(2)	(3)
Moisture	0.83		
Silica, SiO_2	22.84	25.16	24.42
Alumina, Al_2O_3	4.68	6.33	8.16
Ferric oxide, Fe_2O_3	2.46	1.71	3.96
Lime, CaO	39.94	36.08	36.30
Magnesia, MgO	20.17	18.38	16.93
Alkalis $\left\{ \begin{array}{l} \text{Na}_2\text{O} \\ \text{K}_2\text{O} \end{array} \right\}$	1.06		
Carbon dioxide, CO_2	2.22	12.34	10.23
Sulphur trioxide, SO_3	2.47		
Undetermined	2.73		
	100.00	100.00	100.00

- (1) Natural hydraulic cement made at Queenston, Ontario. Sample purchased in Toronto by the writer, 1902, and analyzed by Provincial Assayer for Ontario.
- (2) Natural cement made at Milwaukee, Wisconsin, reported by F. H. Lewis in "Cement Industry," page 170.
- (3) Old Newark Rosendale cement made in the Rosendale district, Ulster County, New York, reported by F. H. Lewis in "Cement Industry," page 170.

THE PHYSICAL QUALITIES OF HYDRAULIC CEMENT.

Hydraulic cement is used as a constructive material and it is wise to determine as far as possible the characteristics which it is likely to develop in practical use before applying it.

In testing the qualities of hydraulic cement from an engineering point of view the following points are to be noted:—

1. Specific gravity.
2. Fineness.
3. Time of Setting.
4. Tensile Strength.
5. Constancy of Volume.
6. Impurities.

The standard specifications for cement used in Canada are

those adopted by the Canadian Society of Civil Engineer copies of these standard specifications may be obtained from the Secretary of the Society, Montreal.

The American Society of Testing Materials in affiliation with the International Society of Testing Materials recommended revised specifications for Hydraulic cement at the last meeting in June, 1904. Copies of these specifications may be obtained from the Secretary of the Society, Philadelphia, Pa.

It is irrelevant in this report to go into details regarding the engineering specifications for hydraulic cements.

III.—AVAILABLE RAW CEMENT-MAKING MATERIALS IN MANITOBA.

The profitable manufacture of Portland cement demands the following conditions:—

- (1) Abundant and cheap supply of suitable coal for power and for clinker kilns. The coal bill is 60% or more of the cost of production in any Portland cement plant using pulverized coal for burning clinker in rotary kilns.
- (2) Abundant supply of raw materials of the correct composition, which should run evenly without marked fluctuations. They should be close together and conveniently located for cheap quarrying.
- (3) A suitable factory site for assembling the raw materials at a low cost and with a good water supply, also convenient shipping facilities for the product.
- (4) A market for the product.

COAL.

There are no workable coal beds in Manitoba although lignite coal occurs in thin seams in the Turtle Mountains and in the Swan River district.

The cheapest available coal is Estevan lignite which, after drying to remove the 20% moisture contents of the mine run coal, should give sufficient heat by burning in a pulverized state in rotary kilns with an air blast.

Estevan lignite has been used at the Arnold Cement Works for making cement clinker in vertical kilns.

Mixtures of North Dakota lignite and Youghiogheny bituminous coal have been successfully used in rotary clinker kilns at the works of the Pembina Portland Company near Milton, North Dakota.

The writer saw lignite fines going to the waste dumps at the rate of 50 tons or more per day in the Estevan coal fields, being discarded for want of a market.

RAW MATERIALS—LIMESTONES, ETC.

From 70 samples of limestones, chalks and marls analysed by M. F. Connor, official chemist, (Report on the Limestones and Lime Industry of Manitoba) the following were found to have chemical composition suitable for use in making Portland cement and are a valuable asset worth further development:—

ANALYSES OF LIMESTONES AND CHALKS IN MANITOBA SUITABLE FOR PORTLAND CEMENT.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Moisture.....	0.09	0.11	0.08	0.03	0.03	0.04	0.05	0.07	0.06	0.04	0.30	0.20
Insoluble.....	1.01	1.10	1.65	3.25	0.65	1.70	1.40	1.65	5.45	5.00	1.24	1.00
Alumina and iron oxides.....	0.35	0.20	0.80	0.74	0.22	0.30	0.42	0.38	1.40	0.92	1.16	0.72
Lime carbonate.....	96.73	96.75	94.82	95.58	95.01	96.81	95.30	95.69	91.24	92.46	94.71	94.86
Magnesium carbonate.....	1.38	1.51	1.87	1.20	0.90	0.90	0.85	1.80	1.50	1.20	2.25	2.68
Sulphur trioxide.....	0.08	0.09	0.09	traces	0.04	0.04	0.08	0.06	0.05	traces	0.14	0.13
	99.64	99.76	99.00	100.23	99.74	99.79	98.10	99.65	99.70	99.62	99.80	99.61

- (1) Steep Rock Point, east shore Lake Manitoba.
- (1a) Steep Rock Point, special sample analysed by the writer.
- (2) Cliff, 1 mile north of Steep Rock Point, east shore Lake Manitoba.
- (3) Onion Point, west shore Lake Manitoba.
- (4) Hog Island, Swan Lake.
- (5) Rosebush Island, Swan Lake.
- (6) Station 89, Swan Lake.
- (7) Mossy River, near Winnipegosis, where the projected C.P.R. crosses the river.
- (8) Snake Island, Lake Winnipegosis.
- (9) Red Deer River, about 3 miles up from Lake Winnipegosis.
- (10) Point Wilkins, Dawson Bay, Lake Winnipegosis.
- (11) Reddish, compact, Cretaceous limestone, found as a bed 2 feet thick on the banks of Assiniboine River, section 36, township 8, range 11, west.
- (12) Gray, rather soft, fossiliferous limestone, found as a bed 2 feet thick above No. 11.

QUARRYING AND SHIPPING FACILITIES.

At Steep Rock Point on the east shore of Lake Manitoba, a cliff of Upper Devonian limestone shows along the shore for about 300 yards, the average height being 14 feet above the water level. The weathered face of the cliff shows a tessellated structure due to the disintegration of the stone into small, irregular pieces, indicating that the stone will crush readily. Fresh fractures show a light gray color, a compact, fine grained texture with a few segregations of crystalline calcite.

The stone can be quarried cheaply, no stripping necessary and barges may run alongside the cliff, as the water is 16 feet deep.

A continuation of the same deposit was noted about 1 mile north of Steep Rock.

The Canadian Northern Railway touches at Oak Point and the Delta on the south end of the Lake and the Canadian Pacific Railway at the Landing on Whitemud River.

At Onion Point on the north-west shore of Lake Manitoba the bed of limestone shows a cliff 8 feet high extending about 150 yards along the shore. The weathered stone breaks into

small, irregular pieces, showing that it will crush easily. Fresh surfaces are light-gray, compact and non-crystalline structure. An extension of the Winnipegosis branch of the C.N.R. will allow access to this deposit.

The limestone on Snake Island (No. 8) cannot be considered as available material as the cost of handling and delivering to the shore would be too great.

It is almost certain that available deposits of high grade limestone exist close to railway facilities near Winnipegosis, as deposits similar to Nos. 7 and 8 have been reported on the shore south and also west of Snake Island. A deposit similar to that on Mossy River where the projected C.P.R. line crosses is also known to be in place about half a mile up the river from location No. 7.

The deposits of high grade limestone on the islands in Swan Lake (Nos. 4 and 5) cannot be considered as available material, as the cost of handling and delivering to the shore to meet coal and shale would be prohibitive.

The advent of the winter season (December 1st) prevented the writer from inspecting this district but is it almost certain that high grade Upper Devonian limestone occurs in place on the west shore of Swan Lake.

J. B. Tyrell, inspecting this district from a purely geological standpoint, reports the following outcrops (Report of Geological Survey Department, 1890-91, page 189E):—

- (1) Light-gray, stratified, slightly argillaceous limestone as a cliff 2 feet above the water, on the eastern side of the Delta of Swan River, N. Latitude $52^{\circ} 27' 45''$, Longitude $100^{\circ} 42'$ west.
- (2) Two miles farther south a cliff 8 feet high, consisting of thick bedded gray limestone, breaking into small fragments, similar to the stone on Rose Island, Swan Lake.
- (3) At the lowest trail crossing on Swan River a cliff showing 8 feet of bedded limestone.

These deposits are worthy of consideration in connection with the shales outcropping near the C.N.R. on the banks of the Swan River and its tributaries.

The limestone outcrops on Red Deer River and Point Wilkins, Lake Winnipegosis, (Nos. 9 and 10) are not within the present boundaries of Manitoba and are not available material, owing to lack of railway facilities.

The outcrops of Cretaceous limestone (Nos. 11 and 12) on the

banks of the Assiniboine River are not at present available material as the nearest railway station (Ladysmith, C.N.R.) is about 8 miles distant. It may be profitable to ship this high grade limestone to the Arnold Cement Works, raising the lime contents of the calcareous shale which is now burned into a high grade natural hydraulic cement. Cars loaded at Ladysmith Station, C.N.R., can be hauled to Arnold Station, C.N.R., without re-handling the material.

The limestone at the following points was found unsuitable owing to high magnesia contents (see Report on the Limestones and Lime Industry of Manitoba):—

1. Tyndal district.
2. Stony Mountain.
3. Stonewall and northward.
4. Lake Winnipeg.
5. Lake St. Martin.
6. Lake Manitoba, excepting three outcrops of Upper Devonian limestone.

MARL AND CHALK DEPOSITS.

Full descriptions with analyses of the marls and chalks in Manitoba are given in the Report on Limestones of Manitoba.

All of the marls examined were found to be low grade, carrying sand or a high percentage of magnesia or both.

Soft yellow chalks of Cretaceous formation are being used for the manufacture of high grade Portland cement at White Cliffs, Arkansas, and at Yankton, South Dakota. As these Cretaceous formations extend northward into Manitoba, a careful survey was made for outcrops of chalk, but the material was found to be variable in composition, carrying considerable finely divided siliceous matter and often a high percentage of sulphates, and is unsuitable for Portland cement. It is possible, however, that some of the outcrops reported from the Porcupine and Duck Mountains may yield suitable chalk.

The writer examined the chalk deposits and calcareous shale in the Tongue River Valley, North Dakota, which have been used for the manufacture of Portland cement at the factory of the Pembina Portland Cement Company, near Milton, North Dakota. He found that the deposits were small and low grade and that the manufacture of Portland cement had been stopped on account of the exhaustion of the supply of chalk.

CLAY SHALES.

Clay shales of Cretaceous formation are known to exist in north-western Manitoba, in the Riding, Duck and Porcupine Mountains, classified according to the following geological table in descending order:—

PIERRE FORMATION	<i>Odanah Series.</i> —Light-gray, hard, fissile shales, poor in fossils, found in the upper portions of the Riding, Duck and Porcupine Mountains. <i>Millwood Series.</i> —Dark-gray, soft shale, often carrying small fragments of selenite and clay iron-stone.
NIOBRARA FORMATION.	Light-gray, mottled calcareous clay shale, with bands of siliceous chalk, everywhere containing the remains of numerous foraminifera. Found usually outcropping at the bottom of coulees and streams below the Pierre shales.
BENTON FORMATION.	Dark-gray soft non-calcareous clay shale, poor in fossils.

Shales were noted belonging to the upper and lower Devonian, but in small quantity.

BENTON SHALES.

Shale of the Benton formation was not noted by the writer, but is reported at the base of the Riding, Duck and Porcupine Mountains in north-western Manitoba. As the lowest member of the series it is likely to be covered by surface detritus from the upper beds.

NIOBRARA SHALES.

The Niobrara formation contains dull gray, soft, calcareous shales often running into bands of soft, yellow chalk containing more or less silica in the form of minute spicules. A characteristic feature of the formation is the presence of the remains of numerous foraminifera as minute white specks in the gray shale. Thin bands of hard, gray limestone carrying numerous fragments of white shells are often present.

The varying composition of the shales is represented by the following analyses, showing that they are generally free from magnesia, low in silica, high in alumina and lime, and usually carry sulphur either in the form of gypsum or as pyrite.

ANALYSES OF CALCAREOUS SHALES OF THE NIobrARA
FORMATION IN MANITOBA.

	(1)	(2)	(3)
Moisture	1.84	2.11	—
Silica, { combined and free }	20.10	16.16	32.50
Alumina	8.20	6.60	14.80
Ferric oxide	3.41	2.45	1.09
Lime	33.76	35.11	40.00
Magnesia	0.78	trace	trace
Alkalis	1.23	1.72	trace
Sulphur trioxide	0.64	3.80	0.40
Carbon dioxide	17.21	26.04	11.00
Combined water }	12.65	5.61	Unde- termined
Organic matter }			
	99.82	99.60	99.79
	(4)	(5)	(6)
Moisture	3.32	1.50	2.30
Silica	13.83	27.02	20.67
Alumina	5.99	9.32	8.70
Ferric oxide	2.59	4.00	3.14
Lime	40.97	35.28	37.00
Magnesia	0.38	0.50	0.50
Alkalis	0.66	1.38	1.20
Sulphur trioxide	0.88	0.82	0.49
Organic matter	7.36	0.41	0.63
Carbon dioxide }	24.02	19.77	25.37
Combined water }			
	100.00	100.00	100.00

- (1) Dark, mottled shale with patches of soft chalk, from Pilling's cement property, Arnold, C.N.R., sample selected by the writer, 1902, and analysed by the Government Assayer for Ontario.
- (2) Average sample of dark shale, Pilling's cement property, Arnold, C.N.R., sampled and assayed as in No. 1.
- (3) Sample of sandy, calcareous shale, from Leary's pit No. 2, Section 13, Township 6, Range 8, west, Boyne River Valley, about 300 yards west of Leary Siding, C.N.R. Analysis by E. B. Young of dried sample for the owners, Leary Land Company, Winnipeg.

- (4) Leary's cement rock deposit, Section 15, Township 6, Range 8, west, underlying the Canadian Northern Railway track and exposed along the banks of the Boyne River. Analysis by M. F. Connor.
- (5) Leary's cement rock deposit (Niobrara shale) outcropping on the banks of the Boyne River below No. 4a, Section 15, Township 6, Range 8, west. Sampled by the writer and analysed by M. F. Connor.
- (6) Same location as No. 3, sampled by the writer and analysed by M. F. Connor.

The writer noted outcrops of Niobrara shale at the following points:—

- (1) On the banks of the Pembina River, Township 1, Range 6, west, near the International Boundary.
- (2) In the coulees of the Pembina Hills near Arnold, especially on Cumming's farm, Moore's farm, and on Pilling's property. The C.N.R. runs over a deposit at Arnold Station where it is mined by the Manitoba Union Mining Company for the manufacture of high grade natural cement.
- (3) On the banks of a stream about two miles north of Deerwood.
- (4) On the banks of the Boyne River, Section 15, Township 6, Range 8, west, within 100 yards of the Canadian Northern Railway track.

Outcrops are reported by J. B. Tyrell (Geological Survey Report, 1890-91) at the following points.

- (1) In the valleys of all the streams on the north side of Riding Mountain from the Ochre to the Valley Rivers.
- (2) On the banks of North Pine Creek, Duck Mountains.
- (3) On the banks of Swan River and its tributaries.
- (4) On the face of Thunder Hill, Swan River Valley.
- (5) On the streams flowing from the eastern and northern slopes of Porcupine Mountains.

The Canadian Northern Railway runs close to most of the outcrops in north-west Manitoba, some of which may be considered as available raw material for the manufacture of Portland cement, especially when the composition of the shale does not fluctuate.

PIERRE SHALES.

The Pierre formation consists of dull gray, fine grained, tough, fissile shales, classified as the Odanah series, and softer, darker shales, often carrying clay-ironstone and small fragments of selenite, classified as the Millwood series.

The writer noted outcrops of Pierre shales at several points in southern Manitoba and they are also reported at the following points:—

- (1) As high cliffs on the banks of Ochre and Vermillion rivers and Edward's Creek on the north face of Riding Mountain.
- (2) On North Pine and Bell Rivers on the east side of Duck Mountain.
- (3) At several points on the east and north faces of Porcupine Mountain.

The Pierre shales close to the Canadian Northern Railway in north-west Manitoba may be considered as available material for the manufacture of Portland cement when they are practically free from sand, magnesia and sulphates. They can be easily pulverized to pass a 100-mesh screen by rolls, disintegrator and dry pan.

Shales similar in composition are used as raw material in combination with limestone for the manufacture of Portland cement in Michigan and Texas, as further described.

ANALYSES OF PIERRE SHALES, MANITOBA.

	(1)	(2)	(3)	(4)	(5)
Moisture					
Combined water } above					
} 100° C....	9.71	6.06	6.78	8.25	10.94
Silica	68.14	79.55	82.65	78.32	61.22
Alumina	8.18	8.35	6.52	7.11	18.90
Ferric oxide	4.10	1.90	2.40	2.59	3.70
Lime	1.67	1.50	0.80	0.91	0.70
Magnesia	1.65	1.02	0.93	1.28	1.10
Alkalis	2.01	1.17	1.30	1.11	3.39
Sulphur trioxide	0.39	undet.	0.16	0.18	traces
Carbon dioxide	1.44	undet.	traces	traces	traces
Organic matter, etc.	3.00	undet.	traces	0.29	traces
	100.29	99.55	101.54	100.04	99.95

- (1) Odanah shale free from sand at La Riviere Brick Works. Sampled by the writer in 1902 and analysed by the Government Assayer for Ontario.
- (2) Compact, light, bluish-gray, tough, smooth shale from the Pierre formation near Souris City, Souris River. Sample collected by Dr. Selwyn and analysed by F. G. Wait (Report of Geological Survey Department, 1892-93).
- (3) Compact, light gray, fissile shale, free from sand, from south bank of Big Creek, a branch of Big Grassy River, north-west corner of section 8, township 17, range 15, west, in Riding Mountain, and analysed by M. F. Connor.
- (4) Pierre shale, found by the writer on banks of Assiniboine River, three miles north of Virden, and analysed by M. F. Connor.
- (5) Pierre shale from cliff, Pembina River Valley, south of Morden, property of Manitoba Cement Company. Analyses by M. F. Connor.

CLAYS.

The writer made a careful examination of the clay deposits convenient to railway facilities in Manitoba with the object of finding a clay-marl which with an admixture of pure marl or chalk would make a good mixture for Portland cement at a low cost.

The results show that the clays of glacial origin carry more or less sand and are unsuitable for cement mixtures; that some of the reassorted boulder clays are fairly pure and free from sand; that the clays derived from the post-glacial erosion of Cretaceous clay shales are fairly pure, free from sand, but often carry finely divided silica; that the clay-marls usually carry sand and magnesia and are practically unsuitable for Portland cement.

Some 50 deposits of clay and clay-marl were examined by the writer in Manitoba and while some of these are suitable for use in making Portland cement (see Report on the Clays and Shales of Manitoba) they are not available material as they are too remote from the high grade limestones in north-western Manitoba.

The following analyses show the composition of a few clays:—

	(1)	(2)	(3)
Moisture	3.65	8.06	6.25
Silica, { combined and free. }	57.28	54.00	45.15
Alumina	17.39	9.25	9.05
Ferric oxide	3.95	2.77	3.75
Lime	2.70	9.77	14.00
Magnesia	1.50	3.51	7.11
Alkalis	2.95	2.34	2.52
Sulphur trioxide	0.10	0.50	0.10
Organic matter	2.00	0.36	1.09
Carbon dioxide Combined water }	8.48	9.90	11.07
	100.00	100.00	100.00

- (1) Clay derived from the erosion of Pierre shale. Sample taken from an excavation for a new line, C.N.R., Boyne Valley, two miles west of Leary Siding. Analysis made by M. F. Connor.
- (2) Stephen's Brick Yard, Portage la Prairie. Yellowish-gray, unstratified, uniform clay, free from gravel and sand. Analysis made by M. F. Connor.
- (3) Eastman's Brick Yards, Gilbert Plains, C.N.R. The deposit is located on section 12, township 25, range 22, west, the C.N.R. passing through the properties. The clay is yellowish, uniform, fairly pure, with only a small quantity of sand. Analysis made by M. F. Connor.

IV.—METHODS OF CEMENT MAKING AND WHERE CEMENT CAN BE MADE IN MANITOBA.

Since it has been proved that the necessary raw materials occur close together in north-western Manitoba, it remains to ascertain the best methods and locations for combining them at the lowest cost to secure the best product.

All of the limestones reported are suitable for the manufacture of Portland cement, when mixed with suitable calcareous shale of the Niobrara formation outcropping at several points along the

Canadian Northern Railway from Ochre River up to the north face of Porcupine Mountain. The extension of the Canadian Northern to the Edmonton coal fields at an early date should allow coal to be laid down at any point in the district for \$3.00 per ton.

SOME METHODS OF MAKING PORTLAND CEMENT FROM LIMESTONES AND CLAYS OR SHALES.

Before erecting a cement factory it is advisable to conduct preliminary experimental tests of the raw material on a commercial scale.

The cheapest way of testing the value of the Upper Devonian limestones and calcareous shales found in north-western Manitoba for making Portland cement is to make a practical test of 100 tons or more at the Arnold Cement Works, operated by the Manitoba Union Mining Company.

The limestone from Snake Island in Lake Winnipegosis may be hauled by sleighs on the ice in winter to C.N.R. cars at Winnipegosis, delivering directly to the cement works at Arnold. The Mossy River limestone may be hauled in winter to Gruber Station, thence by C.N.R. to Arnold.

The most convenient outcrop of calcareous shale is about one mile up the creek above Selater station, but it is practically the same as the shale at the Arnold Cement Works.

In making the test the following operations are necessary:—

- (1) Thorough mixing of the materials in about equal proportions, preferably finely pulverized and pressed into briquettes.
- (2) Either the loose mixture or the briquettes burned in the vertical kiln, as shown in Plate No. 2, using Edmonton coal as fuel.
- (3) The properly burned clinker, carefully selected and free from over-burned and under-burned clinker, pulverized to pass at least a 100-mesh screen.

If the cement shows physical qualities approaching those of Portland cement, then it is safe to predict that the materials will make Portland cement by the improved dry process—dry mixing and rotary kilns.

Since the raw materials in Manitoba are already nearly free from moisture, dry grinding is advisable; and since coal in Manitoba

is expensive, dry mixing will be the cheapest. Pulverized dry lignite coal from Edmonton or Estevan should give sufficient heat in the rotary clinker kilns.

The following methods of cement manufacture using limestone in combination with clay-bearing material are given as examples of modern practice:—

METHOD OF MANUFACTURE IN THE LEHIGH DISTRICT, PENNSYLVANIA, AND NEW JERSEY, U.S.A.

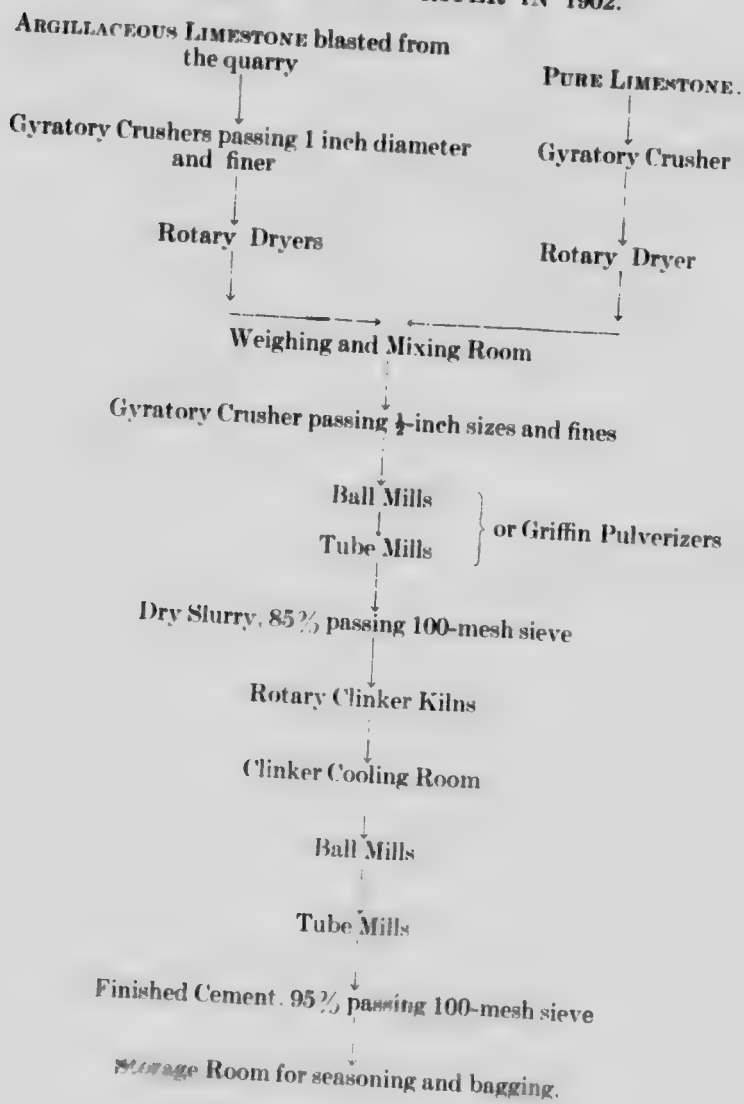
This district has 20 Portland cement plants in operation, producing about 60% of the total output for the United States.

The raw materials are argillaceous limestone and a pure limestone having the following composition:—(Bulletin No. 225, 1904, U.S. Geological Survey Department, Report of E. C. Eckel, page 452).

	Cement Rock.		Argil. Trenton Limestone.		
	(1)	(2)	(3)	(4)	(5)
Silica	15.05	19.06	22.22	19.08	13.80
Alumina	9.02	4.44	7.24	7.92	6.08
Iron oxides	1.27	1.14	0.92		
Lime carbonate	70.10	69.24	63.45	67.07	76.08
Magnesium carbonate	3.96	4.21	4.56	4.06	4.51
	99.40	98.09	98.39	98.13	100.47

	Pure Limestone.		
	(1)	(2)	(3)
Silica	2.14	3.02	1.98
Alumina and iron oxides	1.46	1.90	0.70
Lime carbonate	94.35	92.05	95.19
Magnesium carbonate	2.18	3.04	2.03
	100.13	100.01	99.90

**SCHEME OF OPERATIONS AT THE PORTLAND CEMENT
FACTORIES IN THE LEHIGH VALLEY DISTRICT,
VISITED BY THE WRITER IN 1902.**



METHOD OF MANUFACTURE, EDISON PORTLAND
CEMENT COMPANY, STEWARTSVILLE,
NEW JERSEY.

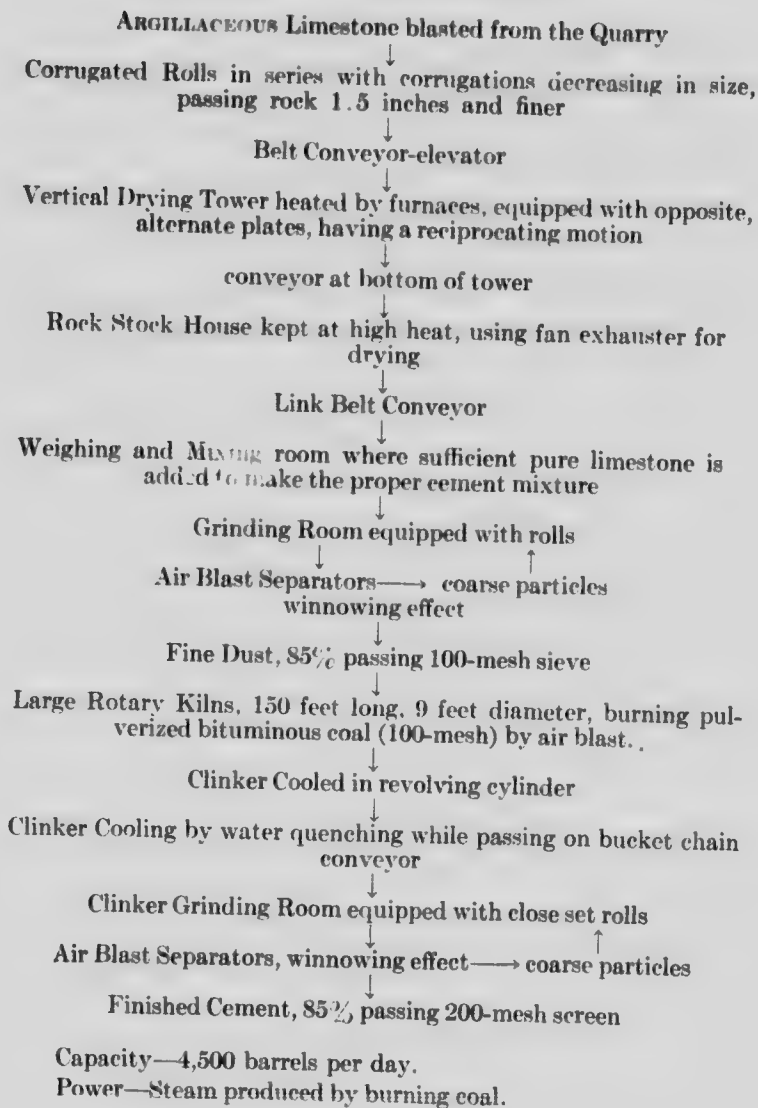
Raw Materials—argillaceous limestone and almost pure limestone, found as alternate beds.

ANALYSES OF CEMENT ROCK, EDISON PORTLAND CEMENT
COMPANY, STEWARTSVILLE, N.J.

	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	CO ₂ (Cal- culated)
1	23.04	8.15	2.41	33.70	0.83	27.40
2	19.32	7.00	1.99	36.86	1.06	30.14
3	19.51	7.05	2.03	36.80	1.18	30.20
4	23.68	8.12	2.57	33.30	1.41	27.57
5	20.29	6.85	2.11	36.84	1.34	30.29
6	19.98	7.23	1.99	36.78	0.58	29.54
7	21.10	7.68	1.92	35.45	0.48	28.38
8	18.15	6.08	1.78	38.00	1.63	31.65

The above analyses show the variation from layer to layer as the drill holes from which the samples were taken traverse the beds at right angles. The analyses were furnished by Mr. Edison for publication in the report of State Geologist of New Jersey, 1900.

**SCHEME OF OPERATIONS AT EDISON PORTLAND
CEMENT WORKS, STEWARTSVILLE, NEW JERSEY.
PLANT FINISHED DURING 1902.**



**METHOD OF MANUFACTURE USED AT THE WORKS OF
ALPENA PORTLAND CEMENT CO., ALPENA, MICHIGAN.
PLANT BUILT ABOUT 1900.**

Raw Materials.—The materials used are a pure limestone and a clay shale, having the following composition (Reports of Geological Survey of Michigan, 1901, and Vol. VIII, 1900-1903):—

**LIMESTONES FROM QUARRIES OF ALPENA PORTLAND CEMENT
COMPANY.**

	(1)	(2)	(3)	(4)	(5)	(6)
Silica.....	0.36	1.77	0.33	0.38	1.38	1.64
Iron oxide }	0.13	0.35	0.18	0.19	1.21	0.27
Alumina }						
Calcium carbonate.....	95.91	89.10	98.37	98.03	96.35	96.50
Magnesium carbonate.....	3.63	8.67	0.92	1.36	0.94	1.26
Total.....	100.03	99.89	99.80	99.96	99.88	99.67

No. 1.—Quarry C. Shell to be removed in stripping. One to two feet thick.

No. 2.—Quarry C. Top strata. Two feet thick.

No. 3.—Quarry C. Second strata. Two feet thick.

No. 4.—Quarry C. Third strata. Four feet thick.

No. 5.—Quarry C. Fourth strata. Two feet thick.

No. 6.—Quarry F. First strata. Two feet thick.

All samples show traces of sulphates and phosphates.

F. M. HALDEMAN,

Chemist

Alpena, Mich., Feb. 12, 1900.

**ANALYSES OF CLAYS AND CLAY SHALES REPORTED TO BE USED
AT ALPENA PORTLAND CEMENT WORKS.**

	(1)	(2)
Silica.....	61.09%	57.98%
Alumina.....	19.19	20.44
Ferrie oxide.....	6.78	3.03
Lime.....	2.51	5.38
Magnesia.....	0.65	2.33
Potassium oxide.....	1.80	3.43
Sodium oxide.....	1.36	
Sulphur trioxide.....	1.42	0.72
Water.....	5.13	6.71
Carbon dioxide.....		
	99.93	100.00

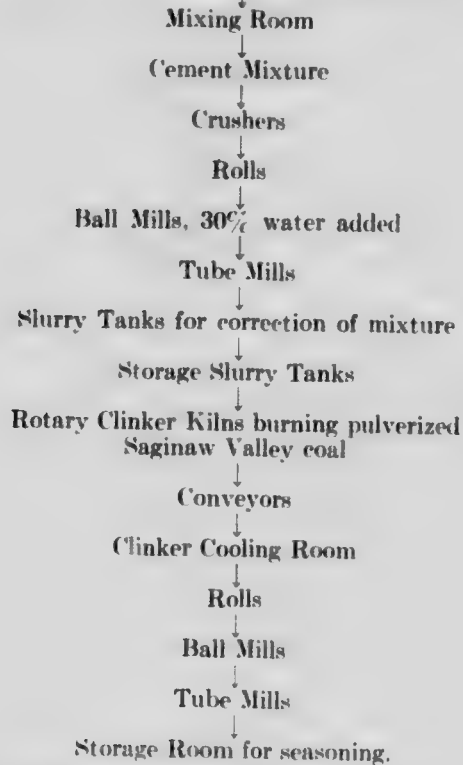
- (1) Clay shale of Hamilton (Traverse) formation; analysis furnished by Dr. H. Ries (Geological Survey of Michigan, Vol. VIII, part I, page 48).
- (2) Upper clays; analysis of dried sample furnished by Mr. Ludlow, the Company's chemist.

SCHEME OF OPERATIONS AT THE FACTORY OF ALPENA PORTLAND CEMENT CO., ALPENA, MICHIGAN.

LIMESTONE.

CLAY SHALE.

Quarry—Cable Cars—Weighing and Storage Bins—Quarry



Capacity, 1,000 barrels per day.

Power: steam, soft coal from Michigan mines used as fuel.
Shipping, railway and boat from Alpena docks to Duluth and Fort
William, Ontario.

METHOD OF MANUFACTURE AT KANSAS PORTLAND CEMENT WORKS, IOLA, KANSAS. THE PLANT BUILT DURING 1903.

The raw materials are the Iola limestone and the overlying Lane shales, both of Cretaceous formation, having the following composition (Report of State Geologist of Kansas, 1903):—

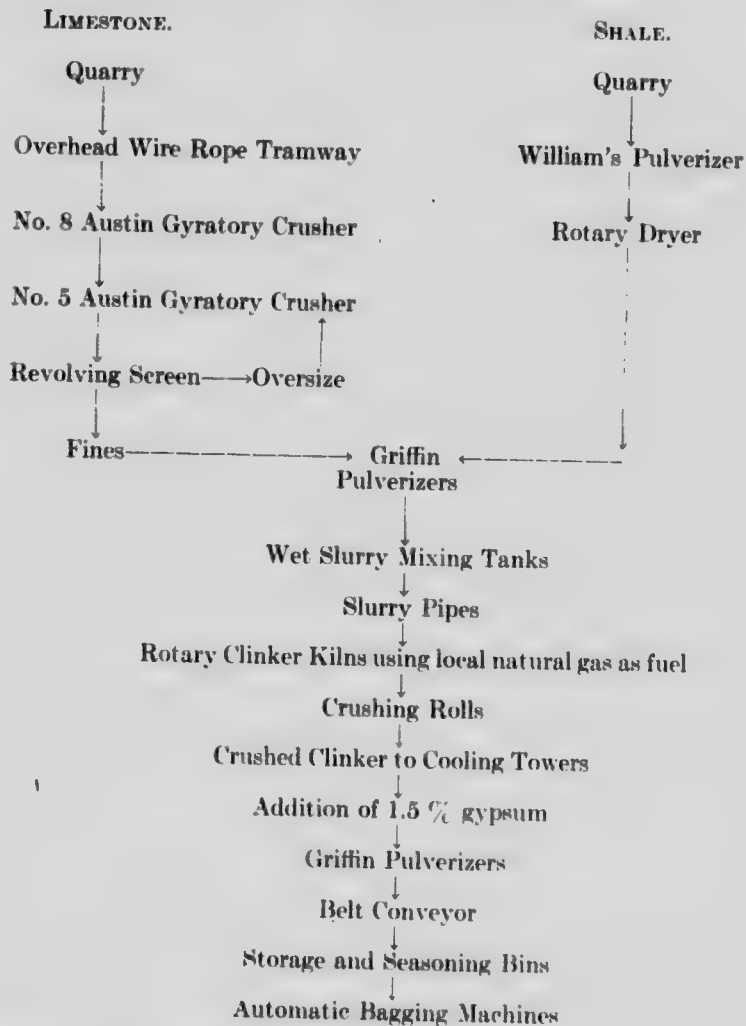
ANALYSES OF IOLA LIMESTONES.

	(1)	(2)
Moisture.....		
Insoluble.....	2.75	2.63
Alumina and iron oxides.....	5.91	1.76
Lime carbonate.....	91.02	94.10
Magnesium carbonate.....	0.14	1.54
Sulphates.....	99.82	100.03

ANALYSES OF LANE SHALES IN VICINITY OF IOLA.

	(1)	(2)
Silica.....	55.00	57.20
Alumina and iron oxide.....	24.36	26.80
Lime.....	0.77	5.40
Magnesia.....	3.30	3.10
Alkalis.....	2.10	3.90
Water { moisture and combined }.....	7.71	7.00
	93.24	103.40

SCHEME OF FACTORY OPERATIONS, KANSAS PORT- LAND CEMENT WORKS, IOLA, KANSAS.



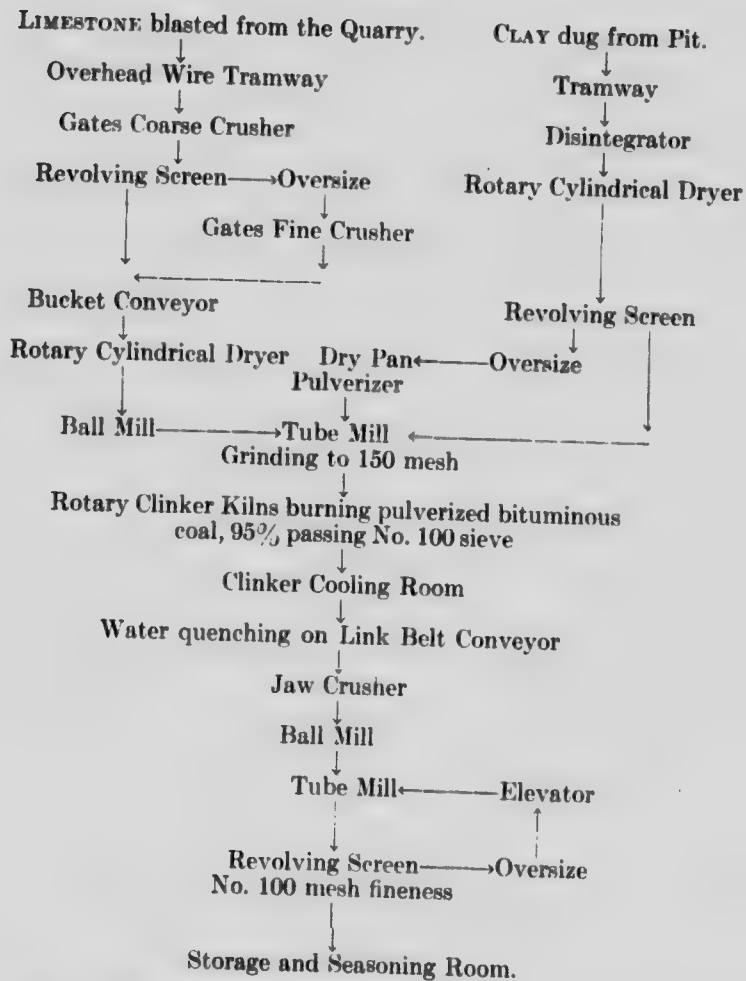
Capacity, 500 barrels per day.

Power furnished by gas engines burning local natural gas.

Cement sells for \$1.25 to \$1.35 per barrel, f.o.b. at the factory.

**SCHEME OF FACTORY OPERATIONS AT THE WORKS
OF INTERNATIONAL PORTLAND CEMENT CO.,
HULL, QUE. PLANT FINISHED MARCH,**

1905.



Capacity, 2,000 barrels per day.

Power, electric.

PROBABLE LOCATIONS FOR PORTLAND CEMENT WORKS IN MANITOBA.

The most favorable location for a Portland cement factory is in north-western Manitoba, but the exact position where the raw materials can be assembled at the lowest cost convenient to coal supply and the market for the finished cement cannot be decided without further examination of the district.

When the extension of the Canadian Northern Railway to Edmonton will allow cheap coal to be delivered in Manitoba, there will be opportunities for the manufacture of Portland cement at some point along the railway from Dauphin to Mafeking Station.

Deposits of calcareous shale are known to outcrop on the banks of the rivers and streams close to the railway and it is quite certain that some of the material is conveniently situated and of suitable quality (practically free from sand, magnesia and sulphates) for the manufacture of Portland cement, when mixed with about an equal proportion of pure limestone.

There is an excellent opportunity near Winnipegosis, already mentioned, as several outcrops of high grade limestone are known to exist close to railway facilities and the outcrops of shale already reported are available material.

Further examination of the high grade limestones on the west shore of Swan Lake and also on the banks of the Swan River, as already reported, may show that they are available material by extending a branch railway through the valley from Swan River Station.

A company was organized recently to exploit the marl deposits east of Gonor Station, C.P.R., but the raw material, as already reported, is not suitable.

A company was organized to establish a cement factory at Morden using the calcareous shale and chalk which are found close together on the banks of the Pembina River, about 15 miles south of Morden, together with imported pure limestone. This cannot be a profitable undertaking as the cost of assembling the raw materials and coal at Morden is too great under present conditions of transportation facilities.

It has been proposed in this report to bring high grade limestone from Steep Rock Lake, Manitoba, to mix with the calcareous shale at the Arnold Cement Works for the experimental manufacture of Portland cement, but the expense of bringing limestone

and coal to Arnold is considerable, so that the operation may be unprofitable on a commercial scale.

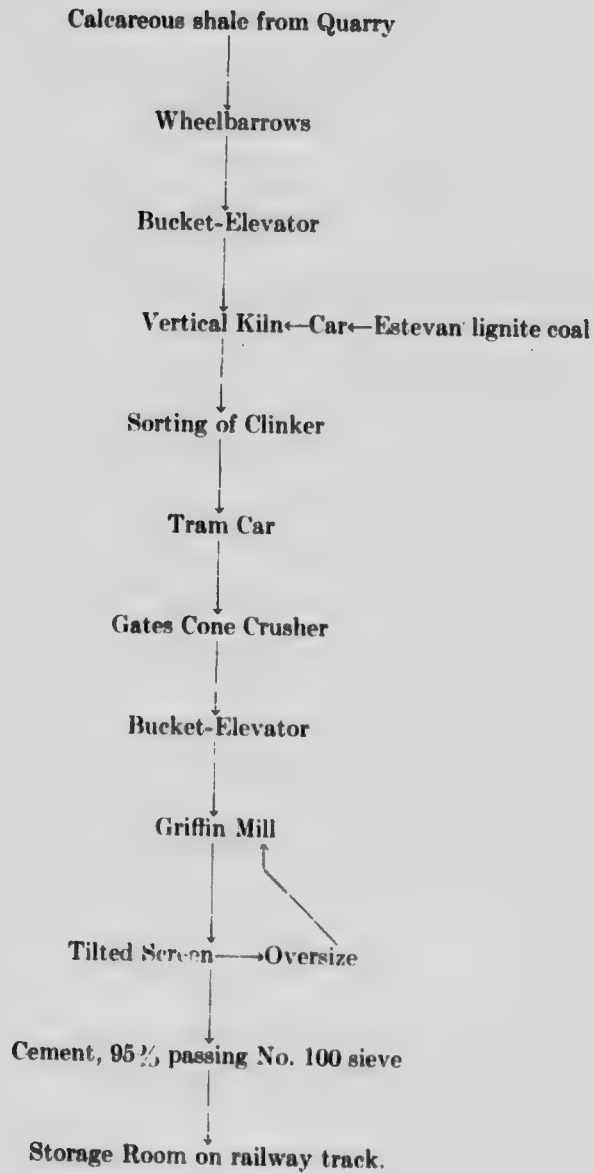
Lignite coal and high grade clay of the Laramie (Tertiary) formation are found in alternate layers in the Estevan coal district, but the expense of hauling pure limestone from north-western Manitoba is considerable, so that under present conditions the manufacture of cement at this point would not be profitable.

Under present conditions of transportation facilities, the high grade large deposits of limestone at Onion Point and Steep Rock Point on the shores of Lake Manitoba cannot be considered as available material. Fairly pure reassorted boulder clay was noted on the banks of Fairford River and no doubt convenient deposits of suitable clay are available, but the expense of shipping coal to these limestone deposits and bringing back the finished cement is too great.

THE MANUFACTURE OF NATURAL CEMENT IN MANITOBA.

Any of the calcareous shales of the Niobrara formation will make a high grade of natural hydraulic cement by calcination in vertical kilns such as employed at the Arnold Cement Works, operated by the Manitoba Union Mining Company, as shown in Plate No. 2.

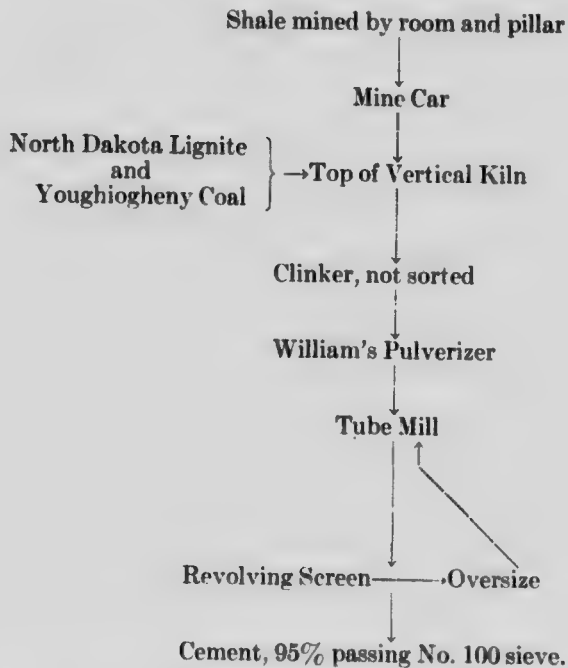
The composition of the calcareous shale found under the railway track is already reported and is made into cement by the following operations:—



Calcareous shale of the same formation is made into a high grade natural hydraulic cement at the works of the Pembina Portland Cement Company, Milton, North Dakota, just south of the Manitoba boundary.

A good grade of Portland cement has also been made, but the supply of chalk necessary for mixing with the shale is exhausted.

The method of operation at this plant is:—



V.—THE USES OF PORTLAND CEMENT IN MANITOBA.

The increasing use of Portland cement in Manitoba is only a natural economic development. Timber is becoming very scarce, suitable building stone often has to be hauled for hundreds of miles, bricks made from clay seem too expensive for common use, while deposits of suitable fine sand, coarse gravel and boulder stones are common, cheap and easily available for use in making cement concrete.

The following list gives some of the more important uses of cement which may be applied in Manitoba, either in the form of neat cement, mortar, plaster, ordinary concrete, artificial stone, monolithic construction or reinforced concrete.

Photographic illustrations show these uses better than written descriptions.

1.—HOUSE AND FARM USES.

Floors for stables, cellars and milk houses.

Mangers, troughs and water tanks.

Fence Posts.

Silos.

Fountains, Pools, Walks and Driveways.

Roofing Tile, Hearth and Facing Tile.

Verandah, Lavatory and Kitchen Floors.

Monolithic Fire-Proof Construction of Houses, Stables, etc.

Culverts and Drains.

2.—RAILROAD WORK.

Water Tanks by the Monier system.

Permanent Culverts and Tunnels.

Abutments, Piers and Retaining Walls.

Foundations for Building and Machinery.

Freight Platforms.

Passenger Depot Floors and Pavements.

Construction of Buildings with the walls covered by expanded metal lath and cement plaster, such as Round Houses, Freight Sheds, etc.

Cinder Pits.

Tunnel Linings.

Piles, especially when attacked by insects.

Railroad Ties and Foundations for Rails.

Telegraph Posts and Butts for decayed Posts.

3.—MUNICIPAL AND GOVERNMENT WORK.

Irrigation and Water Works Dams.

Conduits and Sewers.

Street Crossings.

Street Paving.

Sidewalks, Curbs and Gutters.
 Retaining Walls.
 Reservoirs.
 Culverts and Bridges.
 Locks, Headgates, Dams and Power Houses.

4.—FACTORIES AND MILLS.

Foundations of all kinds.
 Boiler-house and Engine-house Floors.
 Water-proof Pits and Passages.
 Permanent Walls.
 Tannery Vats.
 Water Tanks.
 Chimneys, especially high ones used for factories in large cities.
 Grain Elevators.
 Cold Storage Warehouses.

5.—MANUFACTURE OR CONSTRUCTION OF THE FOLLOWING SPECIALTIES.

Fence and Hitching Posts and Corner Stones.
 Mounting Blocks and Steps.
 Laundry Tubs.
 Vaults.
 Caps, Sills and Columns.
 Artificial Building Stone.
 Art Figures.
 Inlaid Multi-coloured Tile for Floors, Roofs and Facings.

THE USES OF PORTLAND CEMENT AS A MORTAR.

Both natural rock cement and artificial or Portland cement are now being used as a mortar for stone and brick work in place of lime mortar, particularly where ultimate strength and hardness on exposure to water is demanded.

Cement mortar has the following advantages over lime mortar:—

1. Lime mortar is useless in submarine work and durable masonry cannot be laid in water or even in a damp cellar without cement mortar.

2. Weather conditions such as rain, frost, excessive heat have a destructive effect on lime mortar while cement mortar can be made impervious to water, frost, and fire-proof.
3. Lime mortar requires exposure to the air for hardening, while cement mortar sets under water, without contact of air and continues to gain strength for many years.
4. The cohesive and crushing strength of lime mortar is very low, while that of cement mortar is high, depending on the amount of sand added.

PORTLAND CEMENT-LIME MORTAR.

Slaked or hydrated lime is now being added to Portland cement mortar to cheapen the mortar, to render it more impervious to moisture and to make it work smoother under the trowel, as cement-mortar works harsh or short.

F. H. Eno, C.E., after conducting a series of experiments on lime-cement mortars, came to the following conclusions (Bulletin No. 2, Ohio Geological Survey):—

1. That 10 or 20% of lime paste added to cement mortar did not materially affect its strength but cheapened it from $2\frac{1}{4}$ to 5% of the cost of the cement.
2. That any greater per cent of lime paste added decreased the strength of the mortar, without an adequate reduction in the cost.
3. That adding 10 or 20% of cement to lime mortar weakened instead of strengthening the mortar and increased the cost.
4. That the addition of a small percentage of lime paste to cement mortar or of cement to lime mortar reduced the harshness of the mortar in the first case and the stickiness of the mortar in the other, causing it to work much easier under the trowel, thereby a benefit to the mason.

PORTLAND CEMENT PLASTER.

Cement mortar made by mixing Portland cement, lime paste or hydrated lime and sand is largely used as a plaster for making impervious coatings for cisterns, tanks, basements, conduits, etc.

It is also used as interior wall plaster, replacing lime mortar or gypsum cement plaster (hard wall plaster). It is rapidly being introduced, together with expanded metal lath, as a stucco coating for outside walls, replacing wooden weather boards, corrugated sheet iron, brick, etc. The methods of making cement plaster for walls and stucco are given by the various manufacturers of Portland cement. Circulars issued by the Expanded Metal and Fireproofing Company, Toronto, show how expanded metal lath can be used to replace wooden lath in the construction of cementine walls and roofs.

A very thin liquid mixture of 2 parts cement, 1 part sand and water is used as a filler or grouting to fill the joints in street paving made of brick or wooden blocks. Such a filler is durable, impervious and gives good support to the paving blocks.

Artificial stone blocks and various forms of ornamental mouldings are made from Portland cement mortar. The circulars issued by the Roman Stone Company, Toronto, show the method of making such artificial stone, which is being used to replace cut stone and marble.

Cement mortar consisting of 1 part of Portland cement and 2 parts of sand, mixed quite wet, is used as a bed plate for mosaic work made of encaustic tiles, onyx, marble, etc.

Flooring tiles for kitchens, lavatories, etc., are now made of a fine cement mortar in properly constructed dies. They may be colored and polished to resemble marble. Sawdust may be added to the mortar, replacing sand.

Metal work, such as bridges, is now protected from rust by a cement coating or paint made in the following proportions:—

12 pounds of red lead.

32 pounds of Portland cement.

2 pounds of Japan.

Sufficient linseed oil to make a soft putty.

USES OF PORTLAND CEMENT IN COMMON CONCRETE.

Concrete is made by a mixture of cement or hydraulic lime mortar with an aggregate, such as gravel, broken bricks, crushed stone or cinder, the whole forming a solid durable mass, in which the mortar acts as a bond for the aggregate.

For Portland cement concrete a mixture of one part cement to two parts sand and four parts gravel or crushed stone is as good

strong concrete as practically need be used for any piece of cement concrete construction.

A uniform mixture, one part cement to two of sand and six of crushed stone or gravel, makes a concrete of sufficient strength for any ordinary masonry construction when of proper dimensions.

THE PREPARATION OF CEMENT CONCRETE.

The water, sand, gravel and stone used must be clean, to insure good adhesion of the particles. Loam or dirt is the chief enemy of cement.

The sand must not contain clay and should preferably be sharp and not too fine. The best results are obtained with graded sand from fine to coarse.

The stone or gravel should measure from one-half to two inches in diameter. Limestone and hard sandstone crushed into small pieces seem to be better materials than rounded pebbles of gravel, as the mortar cannot get a good hold on the smooth pebbles, but this may not hold good for all grades of gravel.

The best cement mixing machines are those which allow:—
1st. The dry mixing of sand and cement. 2nd. The addition of water and stone with means for continuous mixing, rather than a fixed limit for the amount of mixing.

Hand mixing properly done gives excellent results. Two mixing platforms are generally used, one for the cement and the other for the gravel or broken stone. The dry cement and sand are mixed very thoroughly with a garden rake, so as to distribute the cement uniformly throughout the mortar. The stone or gravel is spread over the second platform to a uniform depth of six inches and thoroughly wetted. The dry mixture of cement and sand is then spread over the wet stone and the whole mass turned over at least four times with shovels and raked meanwhile with a garden rake, to make a uniform mass. Water from a sprinkler may be added as necessary to make a plastic mass. The concrete should be dumped into place, not dropped from a height, as this allows the stone to separate from the mortar. The mass should be tamped till moisture shows on top.

PRACTICAL USES OF CEMENT CONCRETE.

There is no limit for the future use of cement concrete in Manitoba. It is possible to use cement for any structure that

can be made from stone, brick, wood or steel and in many cases it will be done more cheaply with common or reinforced concrete than with either of the other materials.

Unfortunate experiences with natural cement concrete if properly made and used have retarded its development so much that even at the present time some of the conservative Canadian building and loan companies will not loan money to build houses to be constructed of cement concrete for fear that they will tumble down in a year or so.

It is also subject to the marvellous influence of avaricious eagerness and ignorance of many people who do not understand the properties of cement or its proportions, grades and qualities of the other materials which go to make a perfect concrete. For example, an Ontario farmer constructed a concrete foundation for a new barn using one part of Portland cement to twelve parts of gravel when nine parts of gravel would have been risky. When the superstructure was being erected, the walls crumbled so that thirteen men engaged on the work were injured.

FOUNDATIONS AND FOOTINGS.

Cement concrete has the following advantages over stone masonry for foundations and footings:—

- (1) Rapidity with which it can be put in position. A concrete foundation can be placed in one-third the time required for stone and it is ready for the superstructure within 36 hours after it is done.
- (2) It is cheaper, requiring no skilled labour except the foreman.

MASSIVE MONOLITHIC CONSTRUCTION.

It is especially valuable in the construction of massive structures, such as dams, canal banks, reservoirs, abutments, retaining walls, arched culverts, bridge piers, freight platforms, sewers, walls of various kinds, monolithic concrete houses and stables, breakwaters, tunnels, road foundations, curbs, gutters, etc.

For dams, canal banks, sewers, reservoirs, etc., where water is retained, cement concrete is preferable to dressed stone which allows more or less leakage and is generally expensive. The dams, wheel pits, etc., of the electric power companies now constructing

power generating plants on Winnipeg River near Lac du Bonnet are being constructed of cement concrete, although cheap dressed stone is available at the Tyndal quarries.

MONOLITHIC CONCRETE WALLS FOR HOUSES, ETC.

The advantages of concrete are being forcibly presented by the erection of monolithic concrete houses, stables, etc., at different points throughout the Province.

It is calculated that cement concrete (1 part cement costing \$2.75 per barrel and 5 parts gravel costing 50 cents per cubic yard) is cheaper than plank and lumber at \$22.00 per thousand, board measure. It appears that few of the agricultural class of Manitoba are able to handle cement concrete properly so that they use wooden planks and dressed lumber in preference to hiring a stone mason or plasterer to prepare concrete.

ARTIFICIAL STONE BUILDING BLOCKS.

There is a wide field in Manitoba for the use of concrete building blocks, especially in localities where a sand or gravel pit is convenient to the market and to railway shipping facilities and no brick making plants or stone quarries near by.

It is the common practice in Manitoba to use a concrete consisting of 5 parts sand or gravel to one of Portland cement, making under proper conditions a strong and durable artificial stone. A few of the advantages claimed for these blocks are:—

1. Buildings built of these blocks are fire and frost proof, handsomer than those built of brick and require less repairs and insurance rates are generally less than for any other style of building.
2. There is a saving in the cost of construction, especially when a gravel pit is accessible, furnishing cheap and satisfactory gravel.
3. Buildings made of these blocks are warm in winter and cool in summer. The sanitary conditions are superior to those of any solid wall as the outside resists the rain and dries quickly while a solid wall often remains damp all winter. The hollow space allows room for gas pipes, electric wires, ventilators, etc.
4. Buildings constructed with these blocks become more substantial with age while wooden buildings diminish in

strength and as the walls are lighter less foundation is required. The walls require no backing of bricks and plaster can be laid directly on the inside of the walls if desired.

FOUNDATIONS FOR POSTS.

Cement concrete makes a durable butt for iron and wooden posts for all purposes. It is estimated that a saving of 40% is made in refitting telegraph, telephone and trolley poles by the use of cement butts on poles carrying overhead wires. When it is considered that cedar poles decay rapidly, are often burned by prairie fires, and are becoming more expensive every year, railway companies in western Canada should welcome this invention as it cuts down renewal charges, making old poles do the service of new ones, as shown in plate 6. Fence posts are now made of gas pipe set in the centre of concrete bases, 12 inches square and 2 feet deep.

Concrete mileage posts are now used on some of the American railways.

Permanent concrete posts are adopted by the Government Survey Department of Nova Scotia and are far superior to wooden posts, which are soon destroyed.

SIDEWALKS AND STREET PAVEMENTS.

Concrete fills all the requirements for a good sidewalk and pavement for courts and alleys. It makes a smooth walk yet not slippery, does not glaze over with ice quickly like brick walks, does not disintegrate under action of frost, is durable, wears evenly, does not absorb water readily and dries up very quickly. It makes a better and cheaper sidewalk than wooden planks.

ROAD FOUNDATIONS.

Concrete foundations for paved streets are cheap and meet all the requirements.

The cost of concrete foundation was carefully kept in Toronto, Ontario, as follows:—

	Cost per cubic yard.
Cement at \$2.77½ per barrel	\$2.15
Broken stone at \$1.91 per cubic yard.	1.43
Gravel and sand at 80 cents per cubic yard.	0.21
Labor at 15 cents per hour	1.04
Total per cubic yard.	\$4.83
Concrete, 6 inches deep; total per square yard.	0.80

The concrete used was made of 1 part cement, $2\frac{1}{2}$ sand and $7\frac{1}{2}$ crushed stone.

Concrete is also used as a foundation bed for wooden railway ties, as stringers beneath the rails, as concrete ties on ordinary tamped earth or gravel beds and as solid concrete road beds imbedding the rail directly within the concrete mass.*

THE USES OF REINFORCED CEMENT CONCRETE.

Within the last eight years the uses of concrete have been greatly extended by the introduction of iron and steel reinforcements consisting of skeleton structures so arranged in the concrete masses that rods, bars, wires and bands assist in resisting stresses in tension. The success of this combination of materials has advanced concrete to the front rank of building materials for both light and heavy construction. It is stronger and more durable than natural stone, practically fire proof, requires no expense for repairs, is dry and sanitary, comparatively cheap and capable of adaptation to many positions and shapes.

The idea of reinforced concrete was first developed in France by J. Monier and the Monier system has been generally adopted in France and Germany in general building construction.

There are numerous patented modifications of the Monier system, for example:—

- (1) Ransome system, using twisted steel bars.
- (2) Hennebique system, using round steel bars and stirrups to resist shearing forces.
- (3) Thatcher system, using strengthening bars with projections in connection with the concrete.
- (4) Columbian system, using special forms of rolled steel.
- (5) Roebling system, using wire netting and rods as centers for concrete arches.
- (6) Expanded metal system, using expanded sliced sheet steel for slabs but not for beams.

The advantages and methods of using the different forms of reinforcements are best described in the illustrated catalogs issued by the companies operating the different systems.

It is irrelevant in this report to give details, but a few applications as used in Manitoba may be useful.

*The methods of using concrete in these various ways are shown in the *Engineering News*, August 28, 1902, and February 26, 1903.

GRAIN STORAGE ELEVATORS.

A very important application of reinforced cement concrete in Manitoba is the construction of grain elevators. The insurance charges on elevators constructed of wood are high, while the cost of constructing them is gradually becoming higher so that sooner or later most of the grain elevators in the west will probably be made of fire-proof reinforced concrete.

The King Elevator at Port Arthur, Ontario, as shown in the Plate No. 1, is a notable example of the use of concrete reinforced by expanded metal and bars.

The construction of concrete tanks and cylinders by the Monier system seems to be simple and inexpensive and, according to reports, the tanks are equal in every respect to steel tanks, having been used to store grain for some time in Austria, Germany and United States, notably at the Peavey Grain Elevator, Duluth, Wisconsin.

POSTS FOR FENCES AND WIRING.

There is a wide field for the use of fence posts made of reinforced cement concrete in Manitoba as wooden posts are expensive and short lived owing to prairie fires and natural decay, while fences will be more used owing to the gradual introduction of mixed farming and stock raising.

Board fences being too expensive, the fence post which will be most used must be adapted to hold wire fencing in addition to the necessary qualities of cheapness and reliability.

The Durable Cement Post Company, Battle Creek, Michigan, makes a cement butt for wooden posts, as shown in the illustration, also for gas pipes used as fence posts.

Fence posts are now made having a wooden core which is trussed with galvanized wire, this wire being looped to receive each strand of the wire fencing.

Cement fence posts are also on the market having four or more upright strands of stiff barb wire to strengthen the cement.

The writer would suggest the use of a thin angle iron as a reinforcement, as this will resist strains in all directions and can be made very cheaply.

The American Cement Post Company, Athen, Michigan, makes an iron concrete post, as shown in Plate No. 7. Two cor-

rugated iron straps run the whole length of the post, doubling over at the top and bottom. Wire is wrapped around one of these straps and looped out beyond the surface of the cement to form attaching loops either for net or barbed wire fencing.

Corner posts are made $8\frac{1}{2}$ feet long, 8 inches square at the base and 6 inches square at the top, and costing from 30 to 35 cents each. The line posts are much lighter in weight, being $7\frac{1}{2}$ feet long, $3\frac{1}{2}$ inches square at the bottom, $2\frac{1}{2}$ inches at the top, weighing about 60 pounds and costing about 25 cents each. A special machine is used for compressing the concrete into the forms.

These posts combine cheapness, simplicity and strength. In place of the corrugated iron, double strands of barb wire might be used without much loss in strength.

RAILROAD TIES.

A cheap and reliable reinforced railway tie would be a boon to western railways, as wooden ties are expensive and require constant attention for repairs.

Armored concrete ties with an automatic rail gripping device are reported to be used since 1897 on the German State Railway near Briesen, Germany. They are said to be cheap and durable under heavy traffic, while elasticity is given by the patent rail gripping device.

Several American railroads are testing the merits of concrete ties, but so far they have not been used to any extent.

ABUTMENTS, BRIDGE PIERS, ETC.

The use of reinforced cement concrete on railways for the construction of abutments, retaining walls, arched culverts, bridge piers, freight platforms, etc., is extending rapidly. In the construction of new railway lines it appears to be safer, easier and cheaper to build concrete bridge piers, abutments and culverts than to haul dressed building stone. The piers supporting the C.P.R. lines at the Main St. Subway, Winnipeg, are notable examples of reinforced concrete. In this case the reinforcements consist of upright steel rails as used on railroads surrounded by a row of steel rods and incased in concrete made from Portland cement and crushed limestone and gravel, the whole making a strong, cheap support.

LIST OF MANUFACTURERS OF CEMENT BRICK, HOLLOW BLOCK AND TILE.

1. Cement Building Block Company, Merchants Bank Building, Winnipeg, operating the H. S. Palmer and Normandin patent for hollow building blocks.
2. North-west Pressed Stone Company, 177 McDermott Avenue, Winnipeg, operating the Miracle patent. The blocks made by this patent have a double air space which makes a wall built of these blocks entirely frost proof.
3. The Cement Products Company, Ltd., 351 Main Street, Winnipeg, operating the National patent.
4. Canadian Petrified Brick and Stone Company, 540 Main Street, Winnipeg, operating a Berg press making 18,000 concrete bricks per day. This firm also makes hollow building blocks.
5. Brandon Cement Brick and Tiles Works, Brandon. These Works produce cement brick for facing also for filling, hollow building blocks and tiles.
6. A. Whitely, Miami, operating 1 Palmer hollow block machine.

Several parties own machines for local use.

VI.—USES OF NATURAL HYDRAULIC CEMENT IN MANITOBA.

Natural hydraulic cement has been used in Manitoba for several years, having been imported from the Queenston and Thorold Cement Works in Ontario. Recently the Manitoba Union Mining Company, Arnold Station, Canadian Northern Railway, have been producing a satisfactory grade of natural cement which finds a market in competition with the different brands of imported cements.

Ordinary natural cement does not attain the hardness, strength or durability of most Portland cements. The desirable constituents are the same in both, but in the natural cement so much free magnesia, free lime and under-burnt cement are present that it has a tendency to crack and disintegrate. Concrete made of natural cement stands the action of frost fairly well. The low

cost of natural cements allow them to be used in place of lime, thereby raising the standard of masonry construction.

The physical qualities of natural cement demanded by engineers are given in the standard specifications for hydraulic cement.

The most important uses of natural cement are in making:—

- (1) Rough plastering mortar.
- (2) Mortar for brick and stone work in place of lime mortar.
- (3) Cement concrete for floors, foundations, walls, etc.

The manufacturers of the Queenston natural cement in Ontario recommend using it in the following ways:—

- (1) *Plastering Mortar*.—One part cement to two parts of clean, sharp, coarse sand.
- (2) *Mortar for Stone Work*.—One part cement to three parts coarse sand. Mix thoroughly before adding water.

CEMENT PLASTER.

In North Dakota the natural cement made by the Pembina Portland Cement Company is used to make rough plaster coated buildings, such as houses, barns, stables, freight sheds, etc. The usual method of construction is to erect a frame of wooden scantling sheathed inside and outside with half inch second grade lumber, over which is nailed a sheet of herring bone expanded metal forming a skeleton for a coating of natural cement plaster about one inch thick. The plaster consists of one part cement to three parts clean sand well mixed before adding water. A solid foundation is necessary to prevent cracks in the plaster coating, which might allow the entrance of water and the final disintegration of the coating, owing to the action of the frost. The sheeting should be wetted before applying the plaster so that it will not abstract water from the plaster. Cheap and coarse sheeting paper is said to serve in place of wooden sheeting. Such structures are an improvement on the older method of building rough plaster houses, using split boards or wooden lath as sheeting and lime mortar as plaster. They are cheap, warm, and stand the severe weather conditions in North Dakota.

CEMENT MORTAR.

A field for natural cement in Manitoba is the use of cement mortar in place of lime mortar particularly for strong structures made of brick and stone exposed to the action of water.

NATURAL CEMENT CONCRETE.

For natural cement concrete a uniform mixture of one part cement, one part clean, sharp sand and two parts coarse gravel or broken stone may be considered as a standard mixture for a strong concrete to be made with natural cement.

A mixture of one part cement, two of sand and four of crushed stone or coarse gravel makes as weak a concrete as could be made with natural cement for use in any work sufficiently strong to bear the loads usually placed on ordinary masonry.

DIRECTIONS FOR MIXING CONCRETE.

A platform of wooden planks without side boards should be laid level so that the water will mix evenly through the concrete. The gravel used should be clean, free from loam or clay and of different sizes, from coarse sand to 3 inch stones. For ordinary work mix in proportion of one part cement to 6 parts gravel, cinder or broken stone, or one to three when extra strong work is required.

On the platform place the proper proportions of cement, sand and the aggregate until the pile is as large as required for immediate use and in no case use concrete which has been standing over night or even during noon hour. Heap up the mixture in the shape of a cone and turn over twice with a shovel, open from the centre to the sides, leaving the mixture about equal all around. Pour into the centre two pails of water, turn the backs of the shovels from you and push the mixture from all sides into the water, making the shovels go down to the platform every time, so that all the mixture is moistened. Then pour more water all around in the trench, and push in more dry mixture as before. Repeat this till the mixture is all wet. Again pile in the shape of a cone, turn twice over and the concrete is ready for use.

The method of using a box and hoes for mixing is not advisable. When concrete is slushy the sand and gravel sink to the bottom and the cement rises to the top. If it is too soft when rammed down at one place it rises in another, which weakens the cement and makes the mixture irregular.

CONCRETE FLOORS.

For concrete floors the lower layer is made of 1 part natural cement to 6 parts clean gravel, cinder or broken stone. The top

coat should consist of 1 part cement to 3 parts clean coarse sand or fine gravel, firmly rammed and smoothed off, while the lower concrete is still soft. House and cellar floors, when put on dry and firm foundations, need not be over one-half the thickness of others, but the same proportions of cement and gravel should be used.

Such floors are adapted for kitchens, stables, milk houses, cellars, piggeries, etc., and are better than wooden floors for such purposes, as they are durable and can be kept clean very easily.

FOUNDATIONS, ETC.

Natural cement concrete makes a fairly good foundation layer for cement sidewalks, driveways, street crossings, etc. Some of the sidewalks in the city of Brandon have the bottom layer of concrete, using Manitoba natural cement and an inspection of these walks by the writer showed no serious defects, so that it is likely that more natural cement will be used in Manitoba for this purpose, since the sidewalks in the villages and towns are now being built of cement concrete instead of wooden planks.

Natural cement concrete makes an excellent foundation for engines, boilers, vaults and heavy machinery, so that it should find a steady demand for this purpose, especially when the cost of production is reduced so that it can be sold at different points for \$1.25 per barrel.

Natural cement concrete is satisfactory for underground constructions, such as cellars, gutters, sewers and foundations for walls. It sets hard under water and seems to increase in hardness with age. A few years ago some masonry built of stone and natural cement concrete on the Welland Canal was torn down after standing 10 years. The contractor who had charge of the work reports that the cement concrete portion of the structure was harder than the stone and had to be removed by blasting.

CULVERTS AND BRIDGES.

Natural cement from the Arnold Cement Works has been used for culverts and bridge abutments on the Canadian Northern Railway and these structures have stood at least 8 years without repairs.

Concrete culverts are especially useful in swamps where the constant action of water and air destroys wood and iron. Con-

crete culverts on country roads are cheaper than wooden frames. An excellent example was noted about 1 mile west of Altamont Station, Canadian Northern Railway.

Concrete bridges are now being used in Ontario to replace wooden and iron frames over small streams on country roads.

MONOLITHIC WALLS.

For monolithic construction of houses, barns, stables, cold storage buildings, cheese factories, silos, etc., concrete is being more widely used.

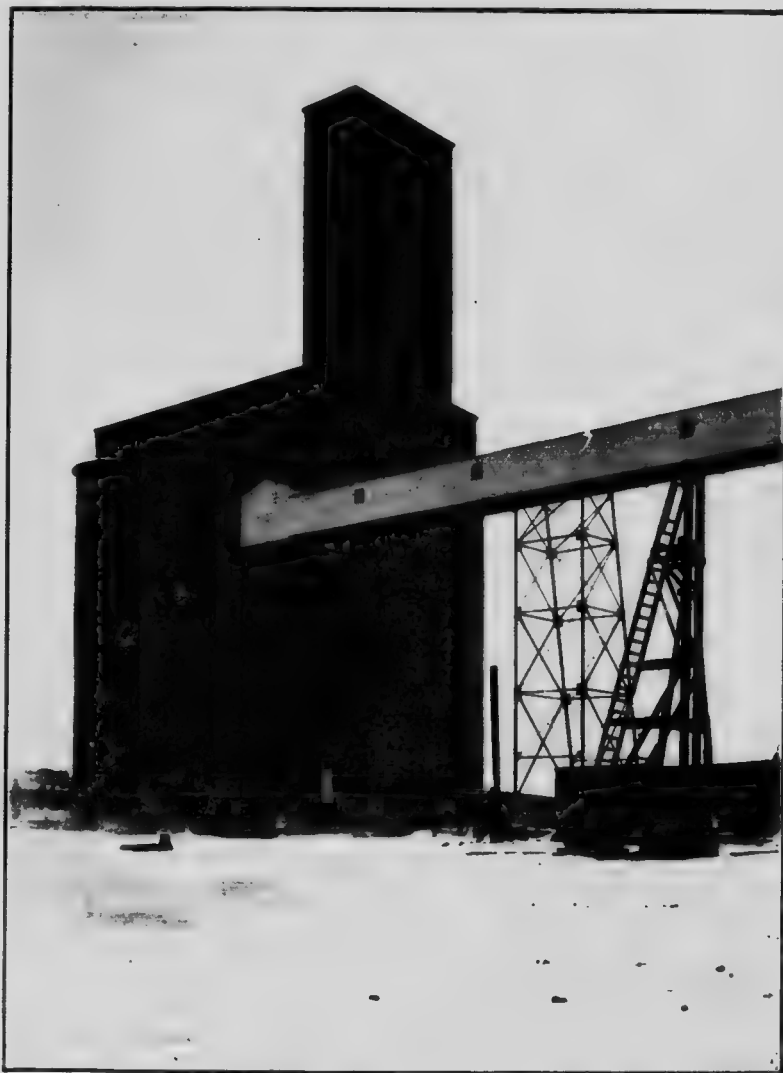
Monolithic walls are made by building up a hollow form of wooden planks leaving a space about 12 inches wide between the planks, which are held in place either by stay-bolts or wires. The hollow space is then filled in with cement concrete made according to the above formula and well rammed down. Door and window frames are put in place as required, as shown in Plate 5.

After the concrete has become hard, the stay-bolts are removed or the cross wires cut, allowing the planks to be taken down. A thin coating of cement plaster is laid on the outside if a smooth wall is required. The walls should not be built in Manitoba later than September 15th as frost prevents the crystallization of the concrete causing it to disintegrate before the hardening process takes place.

The interior surface of the wall may be finished with lime or gypsum cement plaster, either laid directly on the concrete, or better, on lath attached to thin furring, allowing an air space to, prevent frost reaching the interior.

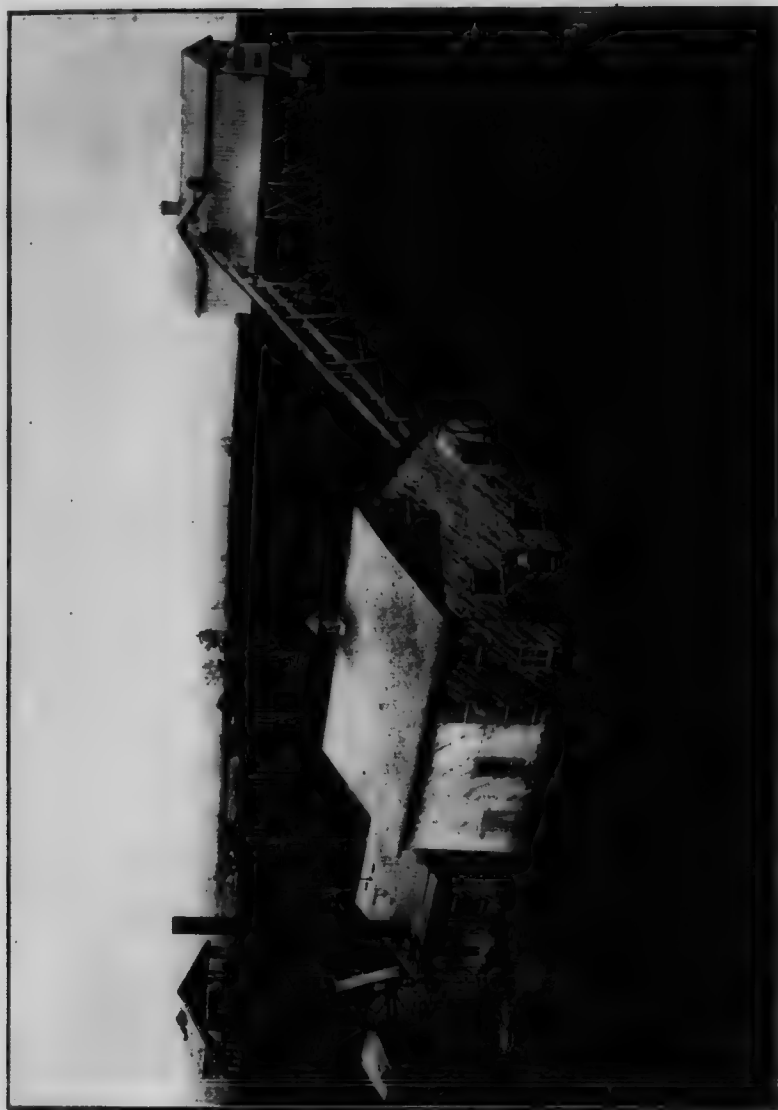
The methods of adapting natural cement concrete to various uses on the farm are well described in circulars issued by the Thorold Cement Works and the Queenston Cement Works in Ontario. An intelligent farmer can find the best methods of using natural cement concrete from the manufacturers' agents in Manitoba and local stone-masons and builders.

PLATE 1.



EXTERIOR VIEW OF THE KING GRAIN STORAGE ELEVATOR, PORT ARTHUR, ONTARIO,
MOSTLY BUILT OF FIREPROOF REINFORCED CONCRETE.

PLATE 2.



VIEW OF ARNOLD CEMENT WORKS, PEMBINA HILLS, SHOWING VERTICAL CLINKER KILN, CLINKER GRINDING HOUSE AND STORAGE SHED ON THE CANADIAN NORTHERN RAILWAY.

PLATE 3.



VIEW OF A NEW DWELLING HOUSE BUILT OF MIRACLE PATENT STONE BUILDING BLOCKS,
AT EMERSON, MANITOBA.

PLATE 4



TYPE OF MONOLITHIC CONCRETE HOUSE BEING ADOPTED IN ONTARIO. THIS HOUSE AT ST. DAVID'S IS BUILT OF NATURAL CEMENT CONCRETE FROM CELLAR TO ROOF, AND THE FOUNDATIONS AND WALLS COST \$670.

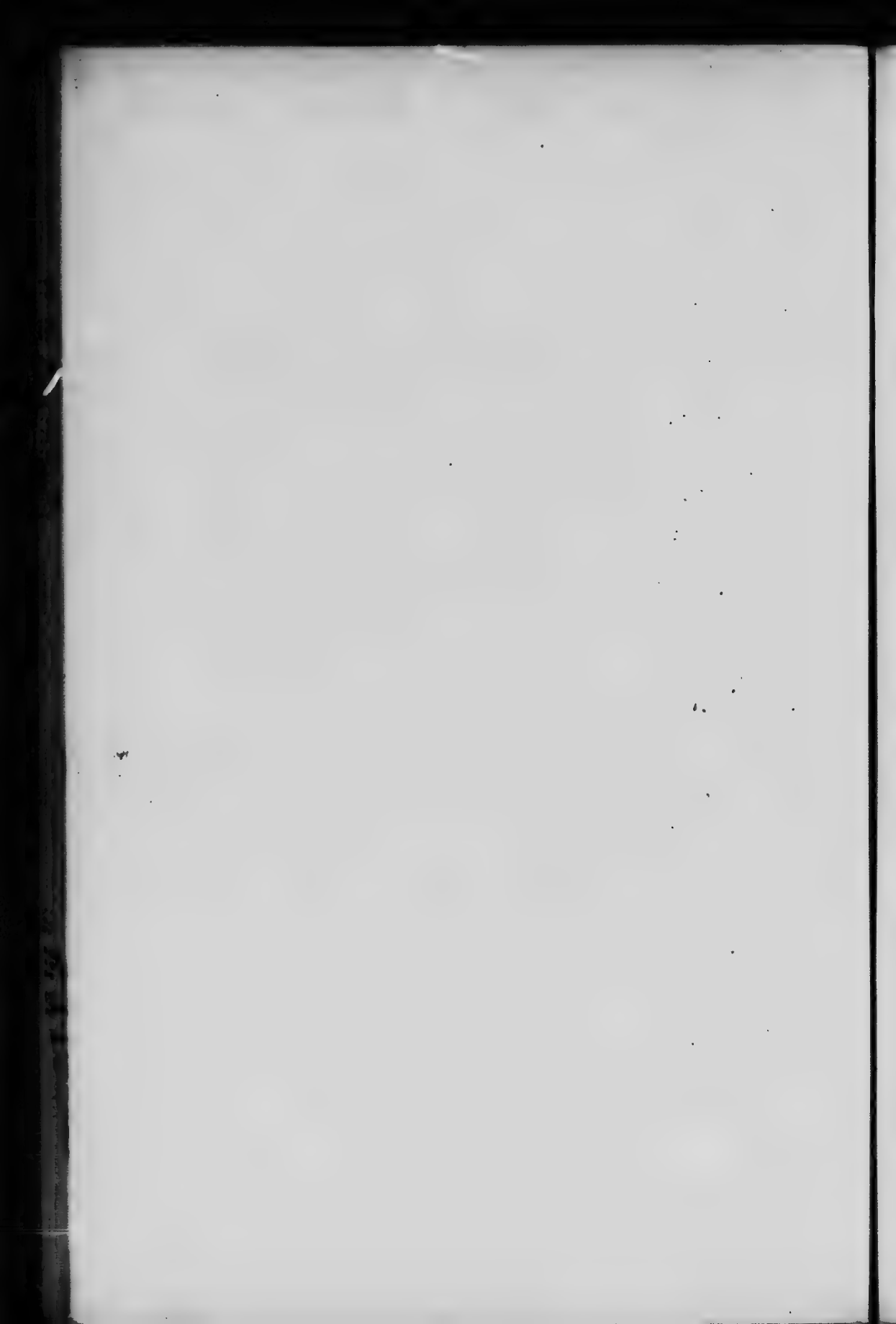


PLATE 5.



A ROUGH MONOLITHIC CONCRETE STABLE AT VIRDEN, MANITOBA.

PLATE 6.

FIG. 1.

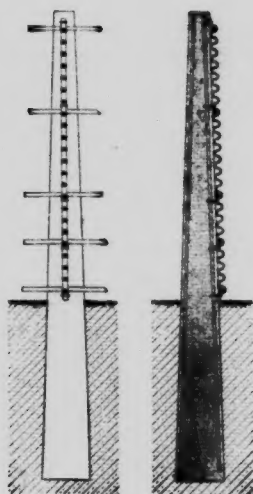


FIG. 2.



METHOD OF REPLACING DECAYED END OF TELEGRAPH POLE
BY A CEMENT CONCRETE BUTT.

PLATE 7.



DRAWING SHOWING REINFORCED CEMENT CONCRETE FENCE POST
USED IN MICHIGAN.